Engineering Library

PRINTED ON THIN PAPER FOR FOREIGN CIRCULATION.

ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY CHAS. COOPER AND J. FOSTER PETREE.

TEMPORARY OFFICES FOR ADVERTISEMENTS AND PUBLICATION, 18 & 20, COMPTON ROAD, HAYES, MIDDLESEX.

VOL. 151—No. 3914. LONDON: FRIDAY, JANUARY 17, 1941. Registered at the General Post Office as a Newspaper PRICE 1s. BY FOREIGN POST 1s. 8d.

FEB 12

S.E.A. RINGS
SYNTHA Packings
EFFICIENCY
RELIABILITY
RONALD TRIST & CO. LTD.,
BATH ROAD, SLOUGH.

INFINITELY BETTER
SPRINGS
SUPER GRADE SPRINGS OF EVERY DESCRIPTION FOR EVERY PURPOSE
On Admiralty, War Office, and Air Ministry Lists. Established 1831
ROBERT RILEY LTD. 9080
Milkstone Spring Works, Rochdale. Tel. 2572

DYSON TRAILERS
R. A. DYSON & CO., LTD.,
GRAFTON STREET, LIVERPOOL 785
Models to carry from 3 cwts. to 150 tons.

J. & E. HALL
REFRIGERATION
FOR LAND & MARINE PURPOSES
LIFTS AND ESCALATORS
J. & E. HALL LTD., ENGINEERS, DARTFORD, KENT.
Telephone: Dartford 3456.
London Office: 10, ST. SWITHIN'S LANE, E.C.4.
Telephone: MANSION HOUSE 9611. 1203

ALL TYPES OF
COLLARS
ALL SIZES. LARGE STOCKS.
H. FORDSMITH LTD.,
Hadfield Street Works, Cornbrook, MANCHESTER, 16.
TRAfford Park 0789 793

GLASS For Machinery
BUTTERWORTH BROS., LTD., 9753
Newton Heath Glass Works, Manchester.

DANIELS
FOR
HYDRAULIC
PUMPS
T. H. & J. DANIELS LTD.
STROUD, GLOS. Phone: 441/2/3.

SPENCER - BONECOURT
Patent Waste Heat Boilers
32, Farringdon Street, London, E.C.4. 868

YARROW
& CO. LTD.,
GLASGOW
SHIPBUILDERS
MARINE ENGINEERS 848
LAND AND MARINE BOILER MAKERS

CRADLEY BOILERS
CRADLEY BOILER CO., LTD., 1068
CRADLEY HEATH, STAFFS.

PETER BROTHERHOOD
PETERBOROUGH LTD.
STEAM ENGINES AND TURBINES,
GAS AND OIL ENGINES,
AIR COMPRESSORS,
REFRIGERATING PLANT.
See advertisement, Page 27, Jan. 10. 6038

CRANES
GEORGE RUSSELL & CO., LTD.,
Motherwell. 816

Research Engineers, Ltd.,
Northampton Grove, Canonbury, London, N.1. Design and construction of mechanical and electrical machinery and apparatus. Experimental work of any description. We have also a department for quantity production on completion of experiments. 1071

LOCOMOTIVES
STEAM OR DIESEL
HUDSWELL CLARKE & Co. LTD.
RAILWAY FOUNDRY, LEEDS
London Office: 46, Victoria St., S.W.1.
Telephone: Victoria 1133 8559

SPRINGS
of every description for all trades. Flat and Spiral.
ROBERT MATHER
CARR SPRING WORKS, RAMSBOTTOM, Near MANCHESTER
Telephone: 2119. Established 1884.

"ACTARC"
Electrodes & Welding Plant
ARC MANUFACTURING CO., LTD.,
ACTARC WORKS, LONDON, W.12.

TRIONITE
NON-FERROUS SAND
CASTINGS
AND CHILL CAST RODS AND TUBES
TRIONITE LTD., STOKE-ON-TRENT 2171

SPECIAL MACHINES
MADE TO ORDER
Parts and repairs
Erection of Plant
Millwrights work 952
THOMAS HUNT & SONS
Westbridge Road, BATTERSEA, S.W.11.

HYDROJET
BABCOCK & WILCOX

RAPIER
WALKING DRAGLINES
RANSOMES & RAPIER LTD.,
Ipswich England 1016
Builders of Europe's Largest
EXCAVATORS

BAXTERS
"PATENTED KNAPPING MOTION"
STONEBREAKERS
and ALLIED SPECIALITIES 756
W. H. BAXTER, Ltd., Leeds, 12

MUREX
Electrodes
1107
MUREX WELDING PROCESSES LTD.,
HERTFORD RD., WALTHAM CROSS, HERTS.

MACROME treated
TOOLS do more
work in less time
MACROME
LIMITED
Z Dept.,
HAY MILLS, BIRMINGHAM
Phone: VIC. 1283-4.

ELEVATORS
BARRY, HENRY & COOK, LTD.
780

MACHINE WORK.
TURNING, FACING, GRINDING, etc.
PLANING UP TO 12ft. 0in. by 4ft. 0in. by 4ft. 0in.
WELDING AND CONSTRUCTIONAL WORK.
EXPERIMENTAL WORK.
ROSSER & RUSSELL, LTD.,
QUEEN'S WHARF, HAMMERSMITH, W.6.
'Phone: RIV. 4416. 9211

Alfred Herbert Ltd., Coventry
PAY BEST PRICES for SECONDHAND MACHINE TOOLS in good condition, by first-class makers.—Write, wire, or phone, and our representative will call. 'Phone 88781 Coventry. Telegrams LATHE, Coventry. W 305

ASH & DUST
LTD., 34, FARRINGDON

For Machine Cut Gears of highest quality — TRY
MOSS GEARS
THE MOSS GEAR CO., LTD.,
Crown Works, Tyburn, Birmingham 8041

On Active Service
COOPER
SPLIT
ROLLER BEARINGS
KING'S LYNN 1158 NORFOLK

WATER PURIFICATION PLANT
OF EVERY DESCRIPTION
JOHN THOMPSON
(KENNICOTT WATER SOFTENERS) LTD.,
WOLVERHAMPTON

BAWN
SHEET METAL WORK.
STEEL PLATE WORK.
Road Tanks. Chemical Plant. Oil Tanks. Air Receivers. Hoppers. Chutes. Ducting. Chimneys. Galv'd Cisterns. Tanks. Cylinders. Guttering. Sinks.
W. B. BAWN & CO. LTD.,
Blackhorse Lane, Walthamstow, London, E.17.
Telephone: LARKwood 4411 (3 lines).

HOWELLS
ELECTRIC
MOTORS

DREDGERS
OF ALL TYPES
FERGUSON BROS. (Port-Glasgow) LTD.
PORT-GLASGOW. 1078

FRICTION CLUTCHES
All Types. Satisfaction Guaranteed.
W. R. ANDERTON & CO.,
Clutch Specialists,
CASTLETON, ROCHDALE 506

ALLDAYS & ONIONS
1132 BIRMINGHAM. LTD.
FOUNDRY PLANT

"The machine with a BRAIN"
SCIAKY
SPOT WELDERS
SLOUGH —— 22342

SLUICING 866
STREET, LONDON, E.C.4

DAVY-UNITED

The illustration shows a 1,100 H.P. Two-Pressure Electrically-driven Horizontal Three-Throw Pump

Hydraulic Pumps

Davy-United Hydraulic High-pressure Pumps have been supplied in large numbers over many years for installations in this country and abroad.

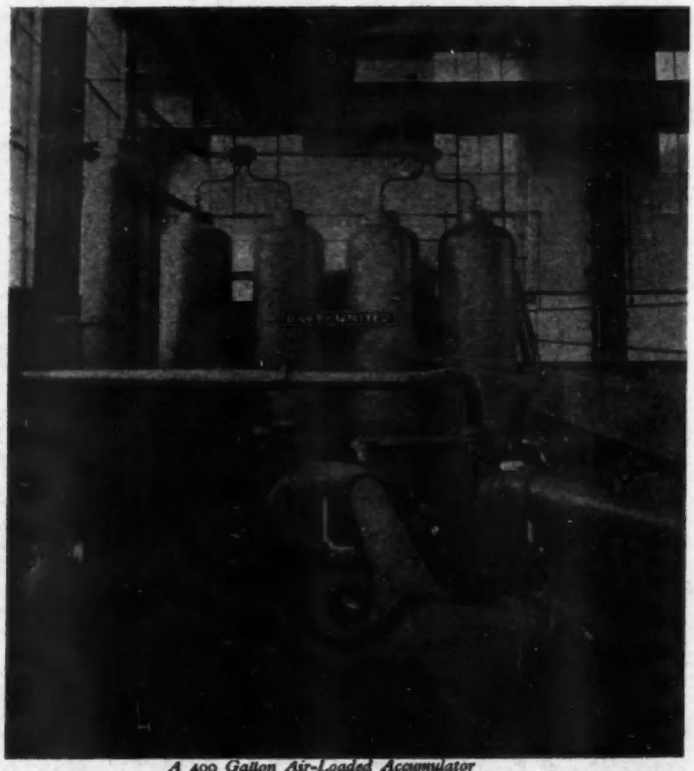
Owing to their sound design and substantial construction, maintenance costs are reduced to the minimum. Latest types embody complete enclosure and oil-pump lubrication for working parts.

Air — Hydraulic Accumulators

The Davy - United Air Hydraulic Accumulator offers many advantages.

Consisting of a water vessel directly connected with an air vessel or vessels, it has no moving parts and freedom from wear and tear is thus assured.

Capacity can be increased by the addition of further vessels. It occupies less space than the weight loaded type.



A 400 Gallon Air-Loaded Accumulator

DAVY AND UNITED ENGINEERING COMPANY LIMITED - SHEFFIELD

DAM CONSTRUCTION IN THE TENNESSEE VALLEY.

(*Continued from page 3.*)

THE preliminary work in connection with the construction of the Norris Dam included the building of a temporary bridge across the Clinch River and the making of a road 48 miles long to enable material to be transported to the site from the town of Coal Creek. These works had to be suitable for heavy lorry traffic. Warehouses, office buildings, repair shops and housing accommodation had also to be provided. The residential property which was built formed the nucleus of the new town of Norris which, after originally acting as the headquarters of the employees of the Tennessee Valley Authority who were engaged on the Norris Dam, has become a prosperous township where many of the employees of the authority reside who are stationed at the Knoxville headquarters. The rest of the community consists of the operating staff of the dam and power house and those engaged in the industries of the area, which have been fostered by the activities of the Tennessee Valley Authority. Preliminary work also covered the sinking of test borings in order to ascertain the suitability of the site for the construction of a dam. Some of the borings were carried down to a depth of 400 ft.

The Clinch River at the site of the dam is about 300 ft. wide and it was possible to carry on the constructional work inside a series of cofferdams consisting of timber cribs filled with clay and broken rock. While construction was proceeding inside the first cofferdams, the river was confined to the still open space alongside them. After completion of the first sections, the water was passed through the discharge conduits in the base of the dam, so that the closing of the final opening could be proceeded with. The first stage cofferdam extended about half-way across the river from the east bank and extended up and down stream for a distance of about 475 ft. It is shown on the plan of the constructional works which is given in Fig. 18, on page 42. After its completion, excavation operations on the east hillside were extended into the bed of the river. Four power shovels were employed on this work, two being electrically driven and two being of the petrol-electric type. One of the shovels was used to dig the foundations for the power house and another cleared the ground for laying the foundations for part of the stilling pool. The other two stripped the overburden and excavated rock from the hillside over the area to be covered by the base of the dam. After work of this kind had been completed at the east end of the dam, the plant was transferred to the west bank and operations were carried on inside the second cofferdam. As will be seen from Fig. 18, a passage for the river was left between cofferdams Nos. 1 and 2.

The total amount of material excavated from the site of the dam and power house amounted to 198,370 cub. yd. of earth and 287,452 cub. yd. of rock. The rock is a hard dolomite, a limestone formation in which part of the calcium has been replaced by magnesium. Sixteen rock drills, mounted on lorries, were kept in operation day and night drilling the rock in order that it could be broken into pieces small enough to be moved. The drills were supplied by three air compressors, each with a capacity of 2,300 cub. ft. a minute and one with a capacity of 1,100 cub. ft. a minute. The delivery pressure in all cases was 100 lb. per square inch. The broken rock and earth was removed by a fleet of 12-cub. yd. and 8-cub. yd. dumping trucks, which were in operation for 22 hours a day.

On the west side of the river, at a point between the dam site and the mouth of Cove Creek, there is a small gulley. An examination of this showed that, below a few feet of earth overburden, the north bank was composed entirely of the type of hard dolomite which had been encountered in the excavation for the foundations. As this was of a quality suitable for the 2,000,000 tons of crushed rock which were required for the construction of the dam, a quarry was opened at this point, which was conveniently situated for transport. The position of the quarry is indicated in Fig. 18, and is well shown in the general view of the completed dam, which is given in Fig. 24, on Plate IV. To open up the quarry, the overburden of earth and clay was washed away by high-pressure nozzles. Three centrifugal pumps were run in series, one being situated at the river bank and the other two at the quarry floor level. The water was pumped over a total distance of 1,200 ft. and to a height of 600 ft., the delivery pressure being 100 lb. per square inch. The nozzles were 2·5 in. in diameter. A view showing this sluicing away of the overburden is given in Fig. 19, on page 43.

For winning the rock, eight of the rock drills mounted on lorries, which had been employed for excavating the foundations, were brought into use. They were fitted with drill-steels in 30-ft. lengths and were used to sink blasting holes in the rock face in lengths ranging up to 300 ft. Jack-hammers were used for secondary drilling. Spoil from the blasting was loaded into 10-cub. yd. dumping trucks by means of two 3-cub. yd. electric shovels. This plant was that which had previously been used to remove 375,000 cub. yd. of earth and rock from the east end of the foundation of the dam. The shovels were supplied with current at 2,300 volts through flexible cables without any difficulty arising. The trucks dumped the rock into the top of a 15-ft. diameter gyratory crusher, 19 ft. high. This was able to deal with a boulder 42 in. long, and reduce it to 6 in. pieces. As the crusher was mounted on the steep hillside, the 250-h.p. driving motor was situated on the quarry floor above and connected to the crusher by a 17-part rope drive. In this way the floor space required for the crusher was restricted to 16 ft. by 16 ft. The position of this primary crusher in relation to the quarry is indicated in Fig. 18. The upper part of it can also be seen in the general view of the quarry given in Fig. 21, on Plate IV. The quarry is on the right of this illustration, which also shows the electric shovels and the road for the dumping trucks.

Rock from the primary crusher was transported across the gulley on a 36-in. rubber-belt conveyor carried on a steel bridge which is shown in Figs. 18 and 21. A further view is given in Fig. 22, which is a reproduction of a photograph of the south side of the gulley taken from the quarry floor. One of the dumping trucks can be seen delivering to the primary crusher. The conveyor had a capacity of 300 tons per hour; a magnetic separator to remove tramp iron was fitted at the head-pulley drive. The conveyor delivered to a secondary crusher on the south side of the gulley. This, which can be seen in Fig. 22, dealt with the 6-in. rock pieces coming from the primary crusher and, through a

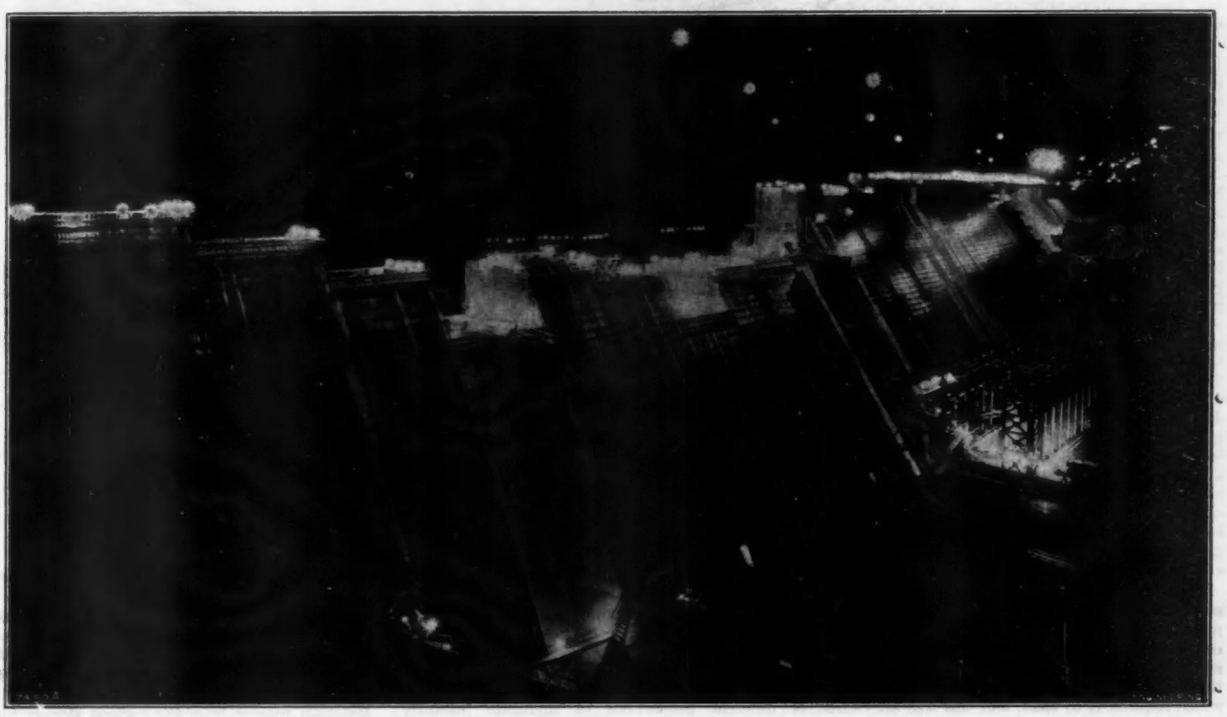
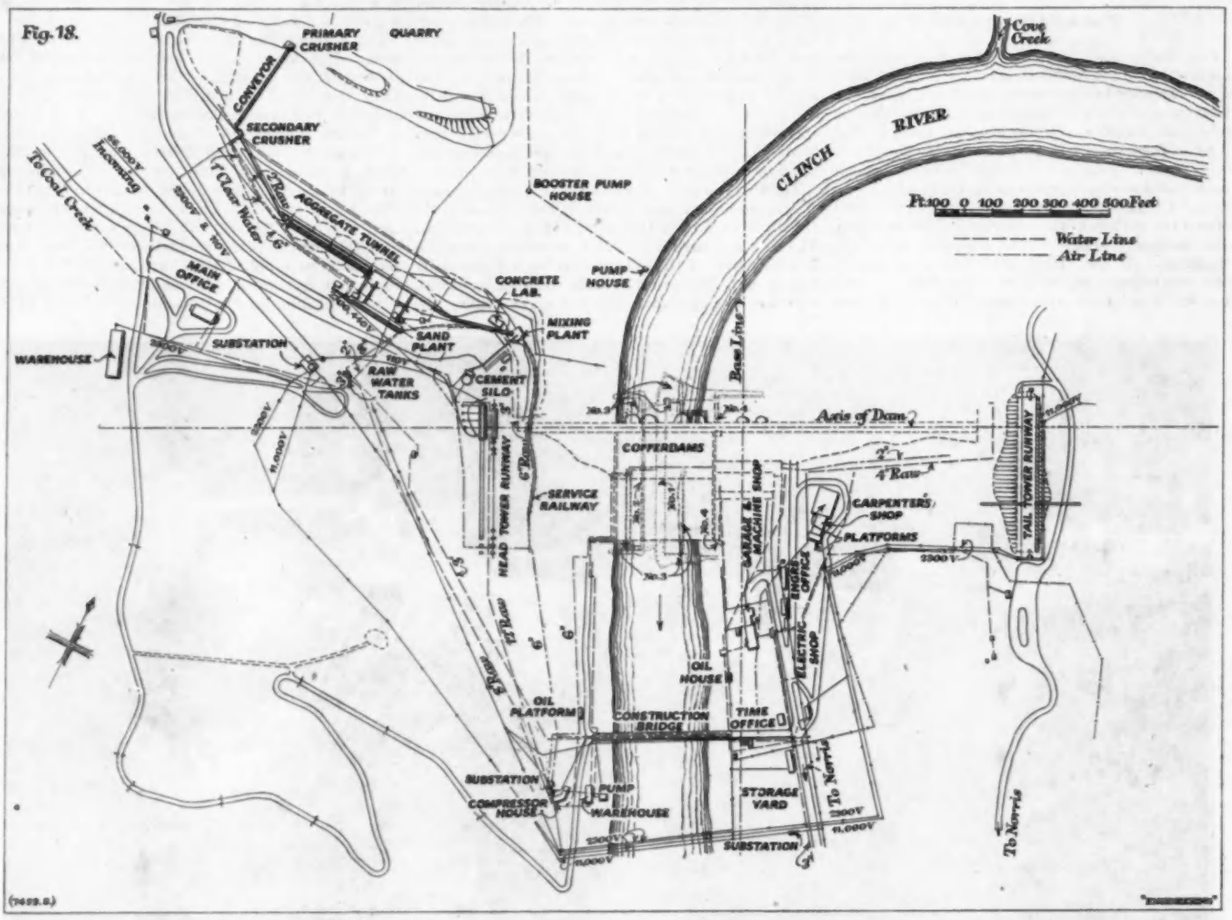


FIG. 17. NIGHT WORK BY FLOOD LIGHTING.

NORRIS DAM ON THE CLINCH RIVER, TENNESSEE, U.S.A.

Fig. 18.



second conveyor, delivered to a series of screens mounted on a steel bridge on the hillside. These can be seen in Figs. 21 and 22. They separated the material into four sizes of aggregate. Part of the broken stone was delivered to hammer mills which reduced it to sand, and this was afterwards screened to two sizes. These mills were situated on the hillside behind the east end of the row of screens. The building in which they were situated can be seen in Figs. 21 and 22. The coarser grade of sand produced varied from 4 to 10 mesh, the finer passing a 4-mesh sieve. The sand grains were of good type, nearly cubical in shape.

The screens and hammer mills delivered the stone and sand to a series of open bins situated on the hillside below the screening bridge. They can be seen in Fig. 21. Running through these bins there was a 6-ft. by 6-ft. concrete tunnel, 646 ft. long. This contained a 30-in. belt conveyor which delivered the aggregate to a further, inclined, conveyor, which led to the mixing plant. The delivery end of the tunnel and the lower end of the inclined conveyor are clearly shown in the left foreground of Fig. 21. A series of gates in the top of the tunnel enabled the proportion of different sizes of aggregate delivered to the tunnel conveyor to be controlled. By means of a system of electric signals, the men at the mixing plant were able to advise the operators of the tunnel gates what quantity of each particular type of aggregate should be delivered.

The mixing plant, the position of which is indicated in Fig. 18, was housed in a five-storey steel tower, which was assembled by means of bolts, instead of rivets, in order that it might be dismantled when the job was finished and transferred to other Tennessee Valley Authority works. A similar arrangement was employed for the greater part of the concrete-materials handling plant. The tower can be seen in the distance in Fig. 22. Its upper part contained storage bins, below which were batching bins, with the mixers at the bottom. The feeding arrangements made five combinations of different proportions of aggregate instantly available at any time, while, with slight adjustments, other combinations were possible. The aggregate, delivered by the inclined conveyor from the conveyor in the concrete tunnel, was discharged into a hopper at the top of the tower, from which it was passed, through a swivel-head spout, to the appropriate individual storage bin. These bins varied in capacity from 140 cub. yd. to 210 cub. yd. On the same level as these storage bins, there were two 470-barrel bulk-cement hoppers.

The whole of the cement required for the 1,000,000 cub. yd. of concrete which were laid in the construction of the dam was delivered by rail to Coal Creek, five miles from the site of the dam. The box cars, in which it was transported, were unloaded by means of two portable cement pumps which delivered to a 6,000-barrel elevated steel silo. From this, 65-barrel capacity road trailers were loaded by gravity. These, which had aluminium tank bodies, carried the cement to the mixing plant. Three of the trailers are shown in Fig. 25, on page 50. The unloading point was situated 230 ft. from the mixing plant and at a level about the same as that of the top of the storage bins in the mixing tower. The trailers discharged under cover, as shown in Fig. 25, into a dumping hopper from which the cement was delivered by two cement pumps either directly to the bin in the mixing tower or to an elevated 6,000-barrel storage silo situated alongside the dumping platform; this is also shown in Fig. 25. Connection between the dumping hopper and the mixing plant was made by a 5-in. pipe suspended from a cable. When it was desired to draw from the storage silo, the cement was passed from the silo to the dumping hopper and then delivered through the same 5-in. pipe.

Materials passing from the various storage bins in the mixing tower were directed into individual batching bins arranged in two batteries, one of three and one of five units. All the batching bins discharged to a common collector hopper from which the combined charges were passed through a power-operated swivel-head which, in turn, discharged to one of three spouts leading to the three mixers. A volumetric water batcher was located alongside the aggregate and cement batching bins and discharged through separate pipes on the swivel head. The mixers were each of 3 cub. yd. capacity and were driven by 40-h.p. alternating-current motors through multiple-rope drives. The total capacity of the three machines was 4,000 cub. yd. of concrete a day, or 180 cub. yd. an hour. The mixers were of the tilting type and were set radially to discharge into a common hopper from which the mix was fed to tilting hoppers carried on three standard-gauge railway trucks. The trucks, each of which had two hoppers, were drawn by a petrol-electric locomotive. They transferred the concrete from the mixing plant to the loading station of two cableways which spanned the site of the dam, 340 ft. above the river. Each truck had a discharge chute in the centre and when the unloading position had been reached the tilting hoppers discharged into this chute, which delivered to 6-cub. yd. bottom-dump buckets that travelled on the cableways. The hoppers were set on rocker arms and were dumped by individual electric motors controlled from the locomotive cab. When they

NORRIS DAM ON THE CLINCH RIVER.

FIG. 19. SLUICING OVERBURDEN AT QUARRY.

FIG. 20. UPSTREAM SIDE OF DAM FROM WEST BANK.

were being loaded from the trucks, the dump buckets occupied a position alongside, but at a lower level than, the railway track.

The two cableways were supported by four structural-steel towers, two on each side of the river. They were carried on double-rail tracks laid parallel to the river channel and could be traversed sideways. The head towers on the west bank of the river were each 75 ft. high, and were located on a bench cut in the hillside; the tail towers, on the opposite bank, were each 110 ft. high and were situated on an earth fill. The tops of the towers on the west bank were 100 ft. above those on the east bank, so that the loaded buckets from the filling station travelled down hill. One of the west towers can be seen at the extreme left of Fig. 22, and the east towers are shown on the far side of the dam in Fig. 23, on Plate IV. The main towers, on each cableway, were 1,925·5 ft. apart. The cables were 3 in. in diameter and contained 165 strands of steel wire, the breaking load being 550 tons. The designed load on each cable was 18 tons, made up of the dumping buckets and cement, plus 28 tons, the weight of the cable itself. The towers had wide bases and horizontal thrust rails were provided. Further anchorage was provided in the form of concrete counterweights, of 388 tons in each head tower and 446 tons in each tail tower. One of the cable anchor towers on the west bank can be seen in Fig. 22.

The dam was constructed in sections, each 56 ft. long and of the full contour on both faces. This procedure is well illustrated by Fig. 20, on this page, which is a view taken from the west bank of the river after completion of the intermediate sections. The concrete was poured in lifts of 5 ft., a minimum of 75 hours being allowed to lapse, after the placing of one lift, before the next was poured. The concrete was puddled, after pouring, by means of electric vibrators, an average of 1½ minutes being necessary to compact a 6-cub. yd. batch of the relatively dry concrete which was used for the body of the structure. This operation is illustrated in Fig. 26, on page 50. The shuttering for one of the 5-ft. lifts and a batch of concrete being delivered from one of the 6-cub. yd. dumping buckets are illustrated in Fig. 27, on same page. This concrete dumping operation was carried on day and night, a very extensive flood-lighting equipment being installed for this purpose, as shown in Fig. 17, on page 41. The sections in which concrete was being laid were illuminated by red lamps in order to guide the cableway operators in delivering the batches to the correct positions. The lamps were carried on two messenger lines for each pair of towers. These were placed 50 ft. apart, so that the lamps hung 25 ft. from the main cables. During the early stages of the work, the messenger lines were allowed to sag, so that the lamps at the middle of the dam hung 50 ft. below the track cables. 1,000-watt lamps were employed. In addition to this main lighting, local illumination was furnished by flood-lights on the towers and smaller lamps in the neighbourhood of the cofferdams.

An interesting feature of the main constructional work was the grouting of cracks and seams in the rock formation under the foundations. An examination of bore holes by means of a type of periscope showed that while the dolomite rock was entirely satisfactory from the points of view of soundness and bearing power, yet various seams existed which might have initiated or permitted seepage. It was accordingly decided that all seams should be cleaned out and grouted. Drill cores showed that seams were not to be expected at a greater depth than 27 ft. below the bottom of the excavation, but that at various intermediate depths there were seams filled with clay. None of the seams was continuous, but in some cases small closed caverns were found. All these openings were cleaned out and sealed with grout.

A series of 5½ in. core-drill holes was put down on a line 20 ft. upstream, and parallel with the axis, of the dam in order to form a grout curtain, or cut-off. The holes, 25 ft. apart, were sunk to a depth of 20 ft.; every fifth hole in the row, however, that is at 100 ft. spacing, was carried to a depth of 50 ft. A definite pattern of 1½-in. holes was also drilled in the area under the apron, with 5½-in. inspection holes 40 ft. deep, at 40 ft. centres. When a group of holes had been drilled, water under a pressure of not more than 30 lb. per square inch was forced into them in series in order to wash out all clay in the seams crossed by the holes. This operation is illustrated in Fig. 28, on page 50. Valve-controlled seals on the holes enabled the water to be forced first into one then into another, so that the direction of flow through the seam could be reversed. This process was continued until only clear water issued from the open hole. The holes and seams were then filled by means of a standard grouting equipment, grout being pumped in as long as the hole would receive it. The cement required for filling a hole varied from one to two hundred sacks. In addition to the inspection holes, referred to above, a series of 36-in. core-drill holes were sunk to a depth of 52 ft. at various positions over the entire foundation. Cores obtained from these gave large-scale samples of the final results.

The periscope, which was used for inspection of the bore holes, consisted of 10-ft. lengths of 3½-in. brass tube, which could be assembled together in lengths up to 40 ft. At the top there was a cap carrying a telescope magnifying to 4 diameters. A mirror was fixed at an angle of 40 deg. at the lower end of the bottom section of tube and below this there was a 200-watt electric lamp. A section of the tube was cut away at the level of the mirror in order to expose the face of the drill hole. Below the mirror the inside of the tube was coated with aluminium paint, black paint being used above the mirror to eliminate reflection. The periscope was supported on a portable A-frame which permitted it to be lowered to any required depth and to be rotated.

The Norris dam was built under the general supervision of Dr. Arthur E. Morgan, chairman and chief engineer of the Tennessee Valley Authority, with Mr. C. A. Bock as assistant chief engineer, Mr. C. H. Locher as constructional consultant, and Mr. A. J. Ackerman as construction plant engineer. Mr. Barton Jones was engineer of construction and Mr. Ross White superintendent of construction.

(To be continued.)

REMOVAL OF KEY INDUSTRY EXEMPTIONS.—The Treasury has made an Order under Section 10 (5) of the Finance Act, 1926, renewing until June 30, 1941, the exemption from Key Industry Duty of all articles at present exempt, except metaldehyde, ethyl orthoformate, and various other chemicals. Copies of the Order, which is entitled the Safeguarding of Industries (Exemption) No. 16 Order, 1940 (S.R. & O., 1940, No. 2,182), may be obtained from H.M. Stationery Office, York House, Kingsway, London, W.C.2.

THE ENGINEERING OUTLOOK.

I.—Economic Retrospect for 1940 and Outlook for 1941.

Owing to the need for withholding from the enemy vital information regarding this country's war effort, practically all the indices of economic activity in the engineering industry, normally appearing in this series, are no longer published. It is not possible, therefore, to present the articles in their usual form. Nevertheless, the past year has seen some very important changes in the organisation of the industry, of which the effect, in many cases, is likely to be prolonged well beyond the end of the war. Further, the publication of *The Annual Trade of the United Kingdom for* 1939 (*Vol. II*) enables some interesting conclusions to be drawn regarding the export trade of the various sections of the engineering industry during the first four months of the war.

During the year, in spite of further intensification of the export drive and the assistance gained from the elimination of subsidised German competition in overseas markets, the development of British export trade has had to face many difficulties which were not foreseen at the outbreak of war. The occupation by Germany of the greater part of Europe has eliminated, as markets for British goods, the majority of the European countries with which many sections of the engineering industry possessed established and growing connections. In addition, the extension of the war to the Mediterranean made shipments to Balkan and near-Eastern markets extremely difficult: while the increased shipping losses, attributable to the withdrawal of the French Navy after the collapse of France and the need for keeping a large part of the British Fleet in the Mediterranean, has intensified the difficulty of shipping to all destinations.

The collapse of France also necessitated a very sudden increase in munitions production in this country, which, in turn, reduced the manufacturing capacity and raw material supplies available to meet export orders. It is not surprising, therefore, that British exports of machinery should have fallen in the first eleven months of 1940 to 34·7*l.* millions, compared with 43·7*l.* millions in the corresponding period of the previous year. An examination of the monthly figures since the outbreak of war shows that the lowest monthly total, 2·1*l.* millions, was recorded in October, 1939. Thereafter there was a steady rise to 5·1*l.* millions in March; a figure which was rather higher than the monthly average for 1938, the best year ever recorded for British machinery exports. At this time it appeared as though British manufacturers were ready to take full advantage of the elimination of German competition, but, as a result of the invasion of Norway and subsequent events mentioned above, machinery exports fell sharply in April and continued to fall until July, when they amounted to only 2·5*l.* millions. Since then there have been considerable fluctuations but, on the average, there has been no material rise. That the decline has been due to the curtailment of markets and the course of the war generally, rather than to special considerations affecting the engineering industry alone, is shown by the fact that a similar trend is apparent in most of the principal categories of British exports. Total British exports rose from 23·1*l.* millions in September, 1939, to 41·5*l.* millions in March, 1940, but fell to 31·2*l.* millions in July, since when there has been little recovery.

United Kingdom exports of machinery in recent years are shown in Table I, herewith, by volume and value for the years up to 1939, and by value only for 1940. It will be seen that the value of exports in 1940, though below the level of the preceding five years, was well above the figures for the slump years 1931 to 1934. The level of exports prevailing at the end of 1940, however, was only just equal to the average monthly exports for 1933, the worst year recorded. As shown in Table II, on this page, there was a sharp rise, amounting to almost 50 per cent., in British imports of machinery in 1940. Although no separate figures are available by categories or countries of origin, this is accounted for largely by the greatly increased purchases of machine tools and other equipment for armament factories from the United States.

As a result of the expansion in the requirements of the armed Forces, the home civil market has been further restricted during 1940. This has been achieved partly through definite restrictions on sales—in some cases, home market quotas have been established, based, for example, on the progress of exports—and partly through the working of the priority system, particularly as regards the allocation of raw-material supplies. In the case of motor vehicles, a permit is necessary before a new private car can be purchased for civil use, while a home market quota linked with the level of exports has been adopted in the case of pedal cycles. Recently, there has been considerable criticism that restrictions on home sales have not been carried far enough, it being argued that the country's war effort would be materially increased if more drastic control were imposed. There has also been a tendency to argue that such control should be extended to cover exports to Empire countries, on the ground that the export of non-essential goods to these countries is equally a dissipation of the war effort. To a considerable extent, of course, such trade in non-essentials has already been reduced by the import restrictions imposed by the Empire countries; and it is probably better that control should come from that side, since, otherwise, there is the danger that the Empire may be forced to meet an increasing proportion of its requirements from other countries, particularly the United States, with more or less permanent reactions on British export trade after the war.

Table I.—*United Kingdom Exports of Machinery.*

Year.	Volume, Tons.	Declared Value (£).	Value per Ton (£).
1913	689,389	33,602,474	48·7
1929	562,263	54,350,821	96·6
1931	329,264	33,011,639	100·3
1932	301,178	29,589,767	95·2
1933	276,312	27,143,286	98·2
1934	388,279	38,593,132	99·3
1935	383,833	39,352,247	102·4
1936	380,495	41,179,280	108·1
1937	438,052	49,740,963	113·2
1938	459,263	57,867,565	125·8
1939	365,950	47,398,109	129·5
1940 (est. on 11 mths.)	—	37,000,000	—

Table II.—*United Kingdom Retained Imports of Machinery.*

Year.	Volume, Tons.	Declared Value (£).	Value per Ton (£).
1913	82,760	5,960,866	72·0
1929	107,874	17,522,792	162·4
1930	101,782	16,363,933	160·8
1931	87,826	14,135,086	160·9
1932	51,997	9,529,649	183·3
1933	41,144	7,846,771	190·7
1934	60,957	10,464,752	171·7
1935	69,489	11,521,856	178·2
1936	100,767	16,181,546	160·8
1937	144,079	22,327,745	154·5
1938	121,247	20,891,237	172·3
1939	—	23,626,235	—
1940 (est. on 11 mths.)	—	34,200,000	—

The most important developments in the engineering industry during the past year, however, have been those undertaken with the object of securing the maximum output of equipment of all sorts for the armed Forces. In this connection, the year divides itself naturally into two parts: the first, up to the collapse of France, when a steady if not particularly rapid expansion in armaments output occurred as a result of the measures instituted on the outbreak of war; and the second, after the French collapse, when it became necessary to plan for a very much larger output than had previously been contemplated. Actually, the French collapse set two main problems: the first was to replace as rapidly as possible the actual loss of equipment suffered by the British Army in France, particularly in view of the risk that invasion might be attempted during the next few months; and the second was so to organise production in this country as to offset our loss to the enemy of the French manufacturing capacity. The first problem could be, and largely was, solved by emergency measures involving a very considerable strain on the labour force concerned. Such a method could not solve the second problem, however, since it was essentially a short-term policy and it was clear that, if no reduction in working hours were made, there would be a serious falling off in individual productivity after a comparatively short period. The solution required a very marked expansion in the available supplies of skilled labour and, although a number of steps were taken both by the Government and the industry in order to ensure this, it could hardly be said by the end of the year that any really substantial progress had been made. In particular, there has been criticism that, as the result of a lawsuit, the Ministries of Supply and of Labour have been too timid in applying the wide compulsory powers conferred on them at the time of the change of Government. The lawsuit in question was brought by the firm of Messrs. E. H. Jones (Machine Tools), Limited, who sought an injunction against two controllers appointed by the Ministry of Supply, one of the grounds of complaint being that the control order would, in effect, override the provisions of the company's memorandum of association. As a result, the original section of Regulation 55 of the Defence (General) Regulations was held, by Mr. Justice Bennett, in the Chancery Division, on August 2, to be invalid. The Government then brought out a new regulation which provided that an authorised controller should not have power to give directions inconsistent with a company's memorandum of association, except in so far as may be provided by the order establishing control of the undertaking. Certain other modifications were also made, and Mr. Justice Bennett then upheld an application for the discharge of the injunction.

The strain on the available labour supplies is clearly shown in Table III, below, from which it will be seen that unemployment in the whole of the engineering industry had been reduced by July, 1940, to 25,755, or only 1·7 per cent. of the number registered in July, 1939. No figures have been published of the numbers registered in July, 1940, but there was certainly a substantial rise compared with the previous year.

Table III.—*Employment in British Engineering Industry.*

	Number Insured.	Number Unemployed.	Number Employed.
July, 1930	1,116,970	177,181	939,789
,, 1931	1,106,600	296,039	810,561
,, 1932	1,079,320	304,656	774,664
,, 1933	1,057,320	239,588	817,732
,, 1934	1,068,900	145,513	923,387
,, 1935	1,092,070	128,514	963,556
,, 1936	1,174,980	86,913	1,088,067
,, 1937	1,297,320	66,607	1,230,713
,, 1938	1,372,040	108,905	1,263,135
,, 1939	1,472,520	65,492	1,407,028
,, 1940	—	25,755	—

As an indication of what was achieved under the emergency programme, Mr. Herbert Morrison, in June, gave the House of Commons some figures for the increase in output of certain categories of military supplies. He said that the increase in the output of cruiser and infantry tanks for June, compared with April, had been 115 per cent.; for carriers, the increase was 64 per cent.; and in a wide range of guns the increase ranged from about 50 per cent. for two items up to 228 per cent. for another. Small arms showed increases ranging between 49 per cent. and 186 per cent., and ammunition of various kinds showed an increase of between 35 per cent. and 42 per cent. He went on to say, however, that fundamental changes were required in many cases in the supply mechanism. In particular, the Parliamentary Secretary to the Ministry of Supply was appointed chairman of the departmental sub-committee of the Production Council, in order to make a thorough overhaul of the Area Organisation of the Ministry and to secure full utilisation of unused capacity. As a result of this investigation, Area Boards were set up in various districts to take charge of local problems. Each Board has six representatives of local industry, three employers and three trade unionists, and five official members representing each of the Departments mainly concerned, namely, the Ministries of

Supply, Aircraft Production, and Labour, the Admiralty, and the Board of Trade. The Boards were charged to seek out latent capacity in each area and to assist Government contractors in the placing of sub-contracts. Industrialists who considered that their plants might be employed on war production were advised to communicate with the Area Boards, and the latter were given power to transfer labour and plant elsewhere if it could not be employed locally. The Boards under the Regional Commissioners will also act as controllers of war production in their areas, should communications break down.

Strong criticisms have also been made from time to time of the whole priority system in force for Government contracts and these criticisms were brought to a head in August in the tenth report of the Select Committee on National Expenditure. The report contained a number of examples of confusion in the priorities system, including cases where the priority of articles was changed from week to week, and others of conflicting instructions from different Government Departments and the issuing of wholly unauthorised priority orders. The Committee declared that neither the Central Production Council nor the Central Priority Department had the necessary organisation to ensure that a general priority direction, applying, for example, to certain specified classes of armaments, was properly worked out or implemented; and it therefore recommended the setting up of an extra-departmental body to compel consuming departments to modify their requirements when necessary in advance of supply difficulties, and proper "progressing" organisation to see that priority orders are speedily carried out. At about the same time that the report was published, Mr. Greenwood admitted in the House of Commons that the priority system had not worked as well as it should and he foreshadowed a more stringent system. Details, however, have not been published of any alterations which may since have been effected in the system.

Undoubtedly the most important problem in securing the maximum war effort is the need for a substantial expansion in the labour force. Early in the year there were complaints regarding the poaching of skilled workmen; a problem which was already giving trouble, particularly in the aircraft industry, even before the outbreak of war. The Select Committee on National Expenditure, in their second report, issued in April, strongly criticised this practice. They pointed out that many advertisements had appeared in newspapers offering bonuses and special attractions in addition to normal remuneration while, in certain districts, labour scouts were sent round in the evenings to persuade skilled workmen to leave their existing jobs and apply for work elsewhere with the promise of increased remuneration. The Committee commented that the fact that certain contractors could afford to pay these extra bonuses suggested that the prices they were receiving were excessive. It is not improbable that this practice was actually encouraged by the increase in Excess Profits Tax to 100 per cent. As a result of this tax, the incentive to earn increased profits was largely removed, but, as it was still important for firms to maintain output, many may have felt that it was worth while to pay higher wages in order to do so. The Government's attitude has been that employers should get together to stop this practice, and it would seem from the diminution in the number of complaints that some improvement was effected towards the end of the year.

Steps to expand the labour force have been proceeding along two main lines. In the first place, attempts were made to secure that no jobs which might be performed by semi-skilled or unskilled labour should be given to skilled workmen and, secondly, there has been a speeding up and expansion of the various Government training schemes. In July, concern was expressed in the House of Commons at the alleged unemployment or under-employment of skilled engineers. The Amalgamated Engineering Union also criticised the misuse of skill, particularly that of their members in the Forces. They stated in May that they had not been successful in getting more than 100 men returned to industry. The Government's reply was that the Area Boards, mentioned above, should substantially improve the regulation of labour supply. The Labour Supply Committees had already begun to function by July, and a staff of labour supply inspectors had been appointed. In August, a full register of all skilled engineering workers was compiled, a step which, of course, should have been taken at the outbreak of war or even earlier. Besides recording every engineering worker in the country and whether he was engaged on essential work or not, the register covered those who were previously engineering workers but who had left for another occupation within the previous ten years.

On the question of training additional skilled workers, arrangements were made in May to provide shorter and more specialised courses at the Government training centres. Originally these centres provided a course of six months, but it was proposed to shorten this in many cases to three months, the aim being to pass 100,000 men through the centres in a year. At the same time, further encouragement was given to the scheme for training by employers, and the Government undertook to pay the fares of men undergoing such training. At the end of June, however, in spite of a sharp increase in the number of entries during the month, the number at the training centres was only about 10,700. By the middle of August, this number had increased to 17,000, but it was estimated that the existing 19 centres could accommodate 25,000 if night-shifts could be worked in all cases. The main difficulty was the shortage of instructors. In September, Mr. Bevin was able to announce that the numbers passing out of the training centres would soon reach 250,000 to 300,000 per annum. This compared with the original goal of only 100,000. It is doubtful, however, whether this figure has, in fact, been reached, since further difficulties have been reported in getting sufficient centres, instructors and machines for training.

Provision has been made to take a certain proportion of women at the training centres. This was rather a thorny matter, involving such questions as equality of pay with men and the fact that the engineering unions had not, in the past, admitted women to membership. Discussions were held in the early months of the year between the Ministry of Labour and the unions and were later continued between the employers and the unions. Towards the end of May, an agreement was reached on the wages to be paid to women. This provided that, for a probationary period of eight weeks, women should be paid at the women's national schedule time rate and bonus. For the next twelve weeks, the basic rate was to be increased by one-third of the difference between the women's schedule rate and that of the men they replaced, while, in addition, they were to receive one-third of the difference between the women's bonus and the men's bonus. For the next twelve weeks, both basic rate and bonus were to be 75 per cent. of the men's rates and, thereafter, women who required no special supervision were to receive the basic rate and bonus applicable to men.

It is clear that energetic measures are still required before a satisfactory solution is reached of the question of man power for the armament and engineering industries. According to the latest official survey of the position, over 1,000,000 additional munition workers (of which 500,000 will probably have to be women) will be required by August, 1941. At the same time there is expected to be a large intake into the Forces, which may still further increase this figure. It is clear that existing training facilities cannot hope to cover more than a comparatively small proportion of this increase and also that the maximum economy in skilled labour is essential. As the Ministry of Labour recently stressed, a reduction in the percentage of skilled men on each job is both possible and imperative.

The question of wages in the engineering industry has now come again to the fore. After accepting an increase of 5*s*. in bonus rates, with effect from the end of February, the unions put forward further claims in July. The claim of the Amalgamated Engineering Union was for an increase of 3*d*. per hour on basic rates and the restoration of the pre-1931 conditions, while the Confederation of Shipbuilding and Engineering Unions claimed a weekly advance of 10*s*. The employers rejected these claims, mainly on the ground that increases of wages for engineering workers, which would necessarily increase the price of munitions, would be contrary to the national interest. After an attempt by extremists to force strike action, the A.E.U. decided to submit their case to the National Arbitration Tribunal, a meeting of which was held on January 7, although, at the time of writing, the result has not been made public. The other engineering unions, acting together as the Joint Trades Movement, originally suggested the constitution of a special tribunal to hear the case.

The whole question of wage increases in war-time, and the danger of inflation owing to the expansion of purchasing power at a time when available goods and services are heavily restricted, was discussed at some length in this series last year. It cannot be denied that, arguing on the usual basis of an increase in the cost of living, the unions have a reasonable case for an increase; but, since the cost of such an increase must inevitably come almost entirely from the public purse, while, in addition, a wage increase in any single branch of industry tends still further to raise the cost of living generally, it would seem that the level of wages is no longer a question which can properly be dealt with by negotiations between employers and employees in individual sections of industry. What is required is a national wages policy applicable to all industries for the duration of the war; the broad outline of such a policy should undoubtedly be laid down by the Government, even if they are unwilling to fix the actual rates of pay.

VOLTAGE-OPERATED EARTH-LEAKAGE PROTECTION.

A PAPER on "Voltage-Operated Earth-Leakage Protection," by Mr. T. C. Gilbert, has been released for discussion by the Institution of Electrical Engineers. In it the author advanced the view that leakage protection problems must be considered upon a more practical basis; in other words, there must be some departure from the present practice of treating the subject in an almost exclusively academic manner. Piecemeal consideration of separate sections of the whole earthing problem, earth electrodes, fuses, earth-continuity conductors, and testing resulted in the obscuration of the question, as efficient leakage protection entailed the perfect functioning of each and every section of the system at the same time and without reasonable chance of failure. In the search for immunity from shock, the equally important matter of protection against fire risk had been overlooked.

Very valuable work had been done by committees of the British Electrical and Allied Industries Research Association, and associated persons, in investigating the safety of consumers in rural areas. In spite of this, however, the fundamental problems seemed no nearer a solution, and no fact had emerged which would justify an assumption with any degree of conviction that a reasonable solution of the earthing problem was in sight. It was reasonable to assume, therefore, that these problems were incapable of solution and new protective systems must be evolved which would be free from all those factors that now vitiated the best designed earthing system constructed under present knowledge. Among such factors were artificial electrode resistance and its district and seasonal variations; the fatal effect of current flowing over electrodes, exemplified in the lethal voltage gradient extending over the surface of the ground; the rating of the fuses controlling the circuit, which were open to unskilled tampering; and the disadvantages associated with interior wiring systems. These were factors which could not be ignored.

As an example of academic consideration, the author mentioned the important matter of voltage gradients usually associated with the earthing of pole-mounting transformers. It was known that a continuance of current flow over such electrodes, which were often unsatisfactory, was responsible for the setting up of a local gradient on the surface of the ground which could be spanned with fatal results by the 4-ft. or 5-ft. length of the common farm animals. These animals seemed to gravitate naturally to the neighbourhood of the pole, with the result that the ground became trampled and muddy. Transformers were often mounted just inside the gateway to a field, so that a maximum number of animals traversed the gradient area. It had been suggested that the transformer electrodes should be quried at some depth with the leads insulated, or that a fence should be erected round the possible gradient

area, which had been variously estimated at distances extending from 5 yards to 50 yards from the electrode. These measures took no account of the gradient which might, and often did, appear at some distance from the electrode, as on the banks of a pond or stream, or at some specially conductive surface stratum. More serious still, however, was the lack of consideration regarding the rise of the potential gradient at the pole electrode, as heavy current at this point could only indicate a serious line or insulation fault, the earthing of a phase line, or the breakage of a line with the end in contact with the ground. Wherever this fault took place another voltage gradient was usually set up, and as its exact location could not be foreseen, no advance protection against it could be devised. Any expensive attention lavished upon the transformer electrode could only at best halve the trouble and could have no effect upon the second, and possibly more dangerously placed, gradient.

Protective multiple earthing, the earthing of the neutral line at multiple points and service lines at the consumer's premises, with all-metal enclosure to the neutral for protection against dangerous voltage rise, had been put forward as a possible solution to rural protective problems, and was receiving a measure of influential support. It should be stated, however, that this was no new method, and had been tried elsewhere as an alternative to ordinary earthing methods. The fact stood out that practically every country that had utilised protective multiple earthing in conjunction with supply voltages of the magnitude encountered in this country had found it necessary to seek some less lethal alternative. America was the outstanding exception, but there were fundamental differences in supply voltages to take into account when making comparisons with that country. Where supply voltages were comparatively low, protective multiple earthing would generally allow neutral voltages to be kept below a dangerous level, say, 50 volts. This was not so likely when higher voltages were employed. The real objection to protective multiple earthing, however, was that the protection it afforded was almost entirely dependent upon the continuity of the neutral. This was even emphasised in the E.R.A. Report F/T 122, which had adequately explored the apparently attractive possibilities of the system. In considering its use, there was, moreover, one other matter which should not be left out of account, and that was the usually poor quality of rural installations.

In any practical examination of the problem all those other, but allied, matters bound up with any protective system must be considered in their proper relation to the main question. The following points must be regarded as essential parts of one whole and applied to earthing, protective multiple earthing or neutralisation: The difficulty of securing and maintaining sufficiently low resistance electrodes of heavy current-carrying capacity to ensure without doubt the isolation of a faulty circuit within a sufficiently short period to eliminate danger; the likelihood of the occurrence of other resistance in the path of the fault current, as in the earth continuity condition of the interior installation or at the fault itself; the operation of the overload protective devices; testing the safety device or system under working conditions; fire risk in the interior installation; damage to apparatus or equipment; effect of the protective system upon the restriction of output; expense; and the desirability of extending leakage protection to cover non-electrical metal in the installation.

In the paper, these points are considered without resource to complicated mathematical formula or very involved calculations because the divergence between theory and practice is more marked in earthing problems than in any other aspect of engineering practice. As a result, it appeared that if ordinary earthing and protective multiple earthing were to continue to hold the field, in spite of their clearly-established disadvantages, heavy cost and liability to cause fire, then some improvement in the electrical and mechanical characteristics of the common wiring systems was essential with proportionate increase in cost. Further, to be effective, any such improvements must be accompanied by the introduction of compulsory wiring regulations and control over those persons calling themselves electricians or electrical engineers. The Electrical Research Association was at present considering the matter of conduit joint conductivity at the instance of the Home Office, and its conclusions should not be long delayed, but there seemed little hope of a compulsory scheme in any other direction.

The author holds the view that the possibilities of all forms of earthing associated with the operation of overload protective devices by means of heavy leakage currents over doubtful and uninsulated conductors had now been so thoroughly investigated without material improvement that attention should be directed towards alternative methods which would eliminate most of the objections enumerated. One of these, which was being extensively used in Germany, Switzerland, Holland and Scandinavia, consisted in the use of special switches in the substations, which had been designed to overcome all the difficulties associated with the protection of rural lines, short-circuit and earth leakage and to prevent the continued existence of excessive voltages on the load side of the transformer. Each switch was fitted with five separate trips of the thermal type, which operated on a common release bar. These comprised three overload trips in the phase lines, one similar trip in the neutral line and an earth-leakage trip. The last of these broke after and made before the phase-line contacts and was tested to ensure that it had sufficient power to trip the switch with certainty when the voltage was gradually raised and at the longest and shortest settings of the delay action. On the other hand, earth-leakage switches for use on consumers' premises had instantaneous trips.

In conclusion, the author reiterated that in this particular examination of the problem his main concern had been fire risk, although the possibly less important problem of shock was automatically solved with any limitation of leakage voltages to low safe values. The matter of fire risk had probably been overlooked for the reason that the evidence of causation was so often destroyed by the resulting fire, as the most perfunctory of examinations showed that in the great majority of installations the potential fire risk was great. This was especially true of the rural installation where the inherent natural resistance of earth electrodes foreshadowed the unisolated—and unisolatable—continuous earth-fault current flowing over an inferior earth circuit made under conditions of ignorance and lack of supervision. According to Fire Office records, the proportion of proved electrical fires was mounting until an unenviable position had been reached in the table of accidents. In the author's opinion, however, this tendency could be reduced very materially by a revision of views on leakage protection, our present methods having been found inadequate in the light of modern developments and requirements.

THE EDGWICK OPTICAL DIVIDING HEAD.

MESSRS. ALFRED HERBERT, LIMITED, COVENTRY.

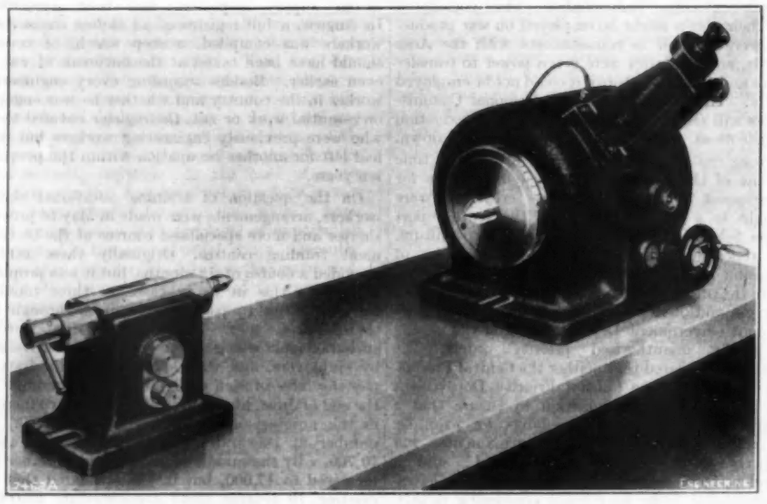
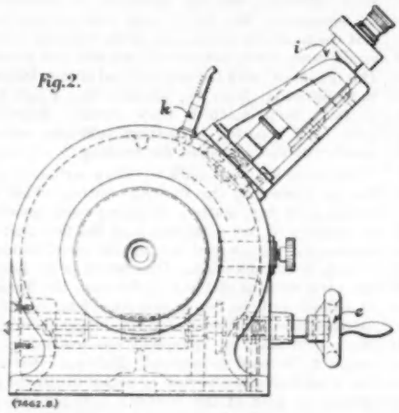
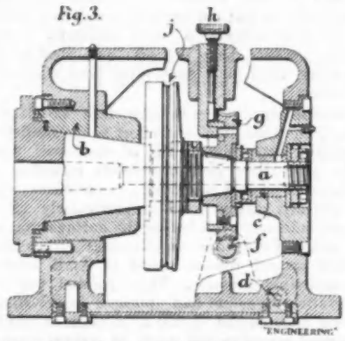


FIG. 1. DIVIDING HEAD AND TAILSTOCK.





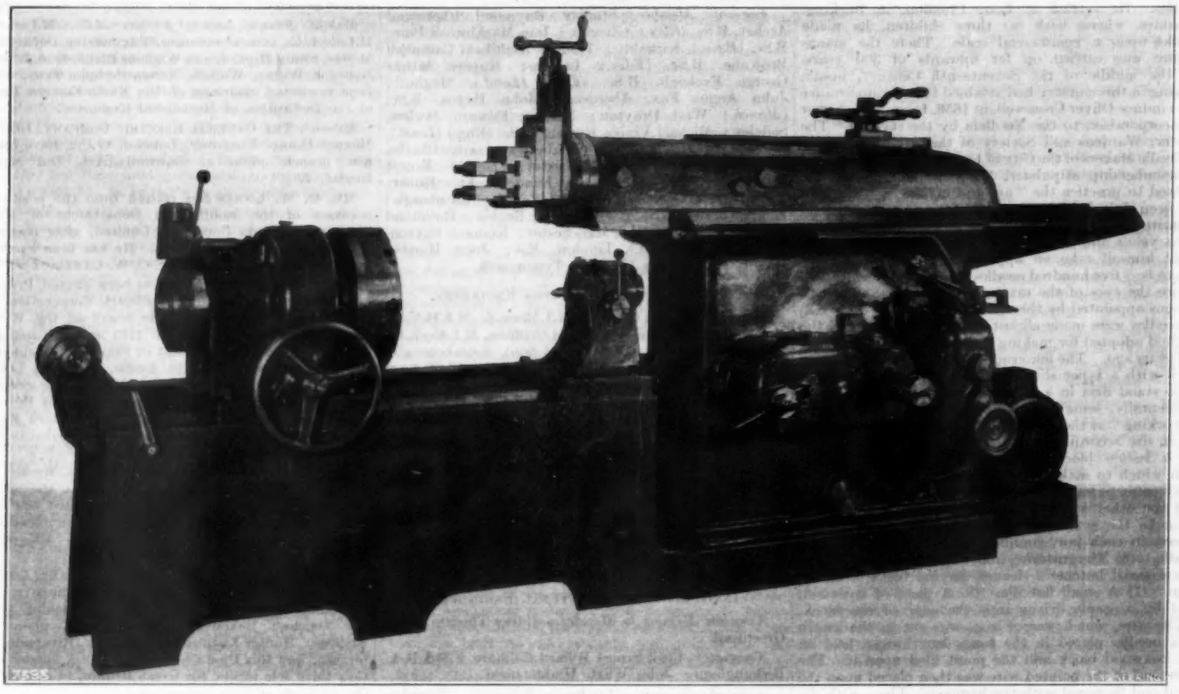
THE EDGWICK OPTICAL DIVIDING HEAD.

THE optical dividing head shown in Figs. 1 to 3, on this page, has been developed and recently introduced by Messrs. Alfred Herbert, Limited, Coventry, in conjunction with another firm of toolmakers, in order to provide an accurate standard of reference for angular measurement which can be used for checking a dividing engine or as a self-contained tool for such measurements on actual tool-room production work. The term "optical" indicates that the readings are made by means of a microscope and not, as might be inferred, by employing a reflected beam of light. The reason for the adoption of this device is stated to be the desirability of discarding mechanical means of division, such as the employment of a worm and wheel in which a micrometer reading on the gear is used for setting, these mechanisms being considered to be liable to inaccuracy, which is increased by wear. The alternative method of setting a sine bar by length standards is generally accurate but is slow and not always applicable, while results may be affected by temperature variations. In the new dividing head, although the spindle is rotated by worm and wheel gear, the settings are made by reading a scale mounted on the spindle, which is then firmly clamped.

An external view of the dividing head and its complementary tailstock is given in Fig. 1, but the construction will be better understood by reference to the drawings reproduced in Figs. 2 and 3. In these views, the spindle, which is of nickel-chrome case-hardened steel, is indicated at *a*. It is hollow and is bored to take a No. 4 Morse taper shank, which can, of course, be readily ejected. The nose is formed with a flange, drilled and tapped to take a Coventry chuck, though, by means of a suitable adapter, other types of chuck can be mounted on it. This end of the spindle is supported in a ground and lapped bearing *b*, of wear-

GUN-BARREL SPLINE-SHAPING MACHINE.

MESSRS. ORMEROD SHAPERS, LIMITED, HEBDEN BRIDGE.



resisting cast iron. The rear bearing *c* is of nickel-chrome case-hardened steel and thrust washers are provided to take axial thrust. The spindle bearings are accurately parallel with the base of the dividing head and an adjusting device is fitted to the bottom of the base so that the spindle axis can be set parallel, or at right angles, as the case may be, in the horizontal plane to the machine spindle or the edge of the inspection table on which the dividing head is in use at the time. This adjustment is effected by screws acting one on each side of a lug on the bottom plate, the screws being indicated at *d*, and being actuated by knurled knobs projecting from the sides of the head.

The spindle is rotated by the handwheel *e*, through two-speed gearing which operates the shaft of a worm *f* meshing with the worm-wheel *g*. Two speeds are provided in order to facilitate coarse and fine setting. For coarse setting the handwheel is pushed inwards, which action engages a dog clutch on the worm spindle and at the same time disengages the double-reduction gears, which enable fine setting to be done when the handwheel is pulled outwards; a free position of the spindle is obtainable when the handwheel is in an intermediate position. The reduction gear has been omitted in Fig. 2, in order to simplify the drawing. It will be seen from Fig. 3, that the wormwheel is provided with a flanged ring, this flange being gripped by the screw *h*, which locks the spindle in the desired setting without disturbing that setting. The actual position of the locking screw is best indicated by the knurled knob seen above the handwheel in Fig. 1. From this view the position of the reading microscope, viz., above the locking knob, will also be clear, its general construction being shown in Fig. 2, in which it is indicated by the reference letter *i*. Its tube is rigidly held in a double Vee-slide attached to a bracket bolted to the head and is provided with a focusing screw.

The microscope axis is radial to the spindle and is directed to the periphery of a disc *j* attached to the spindle. On this periphery is mounted a scale made of silver and graduated with a very high degree of precision, to the full 360 deg., each degree, moreover, being sub-divided into 10 minutes of arc. Accuracy of reading is further contributed to by an optical micrometer in the microscope, which micrometer divides each 10 minutes of arc into 60 parts, therefore giving readings at intervals of 10 seconds of arc. The divisions representing 10 seconds appear in the eyepiece of the microscope to be 0·04 in. apart, so that it is possible to make final readings by estimation to within 2 seconds of arc. Possibly a better appreciation of this degree of accuracy can be obtained when it is realised that with a scale 4 in. in diameter, 2 seconds of arc corresponds to a peripheral measurement of 0·00002 in. As far as we are aware, similar instruments hitherto available have scale graduations of 1 minute of arc only. It will be apparent from Fig. 1 that the flange of the spindle is also graduated. The divisions in this case are in degrees and the graduation has been provided to facilitate coarse setting without having to make continual observation through the microscope. The scale on the spindle disc is illuminated by a "pea" bulb at *k*, in Fig. 2, this small lamp being selected as the heat from it is not sufficient to affect the readings. The current for the lamp may be supplied either from a flash-lamp battery or, through a suitable transformer, from the mains.

It will be clear from the illustrations that all the mechanism of the dividing head is totally enclosed, so that dust, swarf and cutting lubricant are excluded. The rotating mechanism is thus protected from the wear accompanying such common incidents of usage, while the much slower rate of wear arising from normal contacts has no influence whatever on the accuracy of the instrument, the setting being accomplished optically. As there is no wear of the optical parts, the original accuracy can, therefore, be maintained throughout the life of the dividing head. The tailstock, seen on the left in Fig. 1, has a hardened and ground spindle with eccentric and vertical adjustment for alignment of the centres. Adjustment in the horizontal plane is effected by turning the barrel in which the centre is mounted eccentrically, while correction for height is made by means of a nut at the side of the tailstock base. The alignment of the centres is checked by a dial gauge mounted on a trammel which is carried by an arbor held between the centres of the dividing head and tailstock. The anvil of the dial gauge makes contact with the face of the spindle flange of the head. The spindle is then rotated and adjustments are made to the tailstock until a constant reading round the whole circle of contact is obtained.

CONCESSIONS REGARDING WIDTH AND TYRES OF MOTOR VEHICLES.—A new amendment of the Motor Vehicles (Construction and Use) Regulations alters paragraph 37 to read: "The overall width of a motor car shall not exceed 7 ft. 6 in." The previous limit was 7 ft. 2 in. A further amendment postpones, for another year, the requirement concerning the fitting of pneumatic tyres in place of solid tyres on motor vehicles and trailers.

GUN-BARREL SPLINE-SHAPING MACHINE.

THE 26-in. stroke shaping machine for forming splines on gun barrels, shown in the accompanying illustration, is a recent addition to the range of shapers for this purpose manufactured by Messrs. Ormerod Shapers, Limited, Hebden Bridge. The machine has been developed from the firm's standard spline-shaping machine and is capable of working on barrels up to 6¼ in. in diameter. The shaper proper is mounted on a heavy bed furnished with a sliding headstock, a fixed tailstock and a roller steady. In general, the shaper embodies Messrs. Ormerod's usual practice. It is driven by a motor mounted on the end of the bedplate and transmitting power through multiple Vee-ropes, a nine-speed gearbox, and a friction clutch. A brake, inter-connected with the clutch-operating mechanism, enables the machine to be stopped in any desired position. The stroke is variable and the length in use at any time is indicated on a direct-reading dial. The cutter head is arranged to swivel on the ram and has a micrometer dial for setting. Five rates of automatic feed are provided, ranging from 0·005 in. to 0·025 in. per stroke, the lowest notch on the feed quadrant seen in the illustration being for setting the machine for hand feed. Pressure lubrication is provided, and the pump is fitted with an inlet filter and a pressure gauge.

The work is carried in the hollow forged-steel spindle of the headstock, which is traversed by screw along the bed until the work is in the correct longitudinal position relative to the stroke of the cutting tool. The barrel is then gripped in the spindle chuck. For dividing, the spindle is rotated by means of a six-speed gearbox through spiral gearing, and a phosphor-bronze worm-wheel meshing with a worm of high-tensile steel, running in an oil-bath, provision being made to eliminate backlash. The dividing plate is of hardened steel and is mounted at the rear of the spindle. A spring-loaded plunger engages with the plate at the indexing points. A readily-operated tool-setting device ensures the setting of the tool exactly on the centre line of the work-piece. The roller-steady at the rear is intended to act not so much as a support to the work as to facilitate its easy loading into the spindle. The large handwheel seen in front of the headstock is for the rapid rotation of the spindle by hand. The weight of the unloaded machine is approximately 4 tons 5 cwt., and the floor-area required is 12 ft. 6 in. by 4 ft. 6 in., the length, of course, being exclusive of any space required by overhanging work.

EARLY NEEDLE MAKING.*

By GEORGE WHITE, M.I.Mech.E.

THE period to which this paper refers commences around the year 1560, the time of Christopher Greening, who was the first Englishman known to have made needles. He settled at Long Crendon, in Buckinghamshire, where, with his three children, he made needles upon a commercial scale. There the manufacture was carried on for upwards of 300 years. By the middle of the Seventeenth Century, needle making in this country had attained to such importance as to induce Oliver Cromwell, in 1656, to grant a charter of incorporation to the Needlers by the style of "The Master, Wardens and Society of the Art or Mysterye of Needle Makers of the City of London." The conditions of membership stipulated that no man was to be allowed to practice the "art and mysterye" who had not been duly bound apprentice for seven years; and a master must have been out of his apprenticeship three years and "make his proof piece" before he could himself take an apprentice. This proof piece was to be "five hundred needles made by his own hands, before the eyes of the master and wardens, or of two persons appointed by them."

Needles were made almost entirely by hand and the method adopted for making them persisted until about 120 years ago. The few crude tools were (1) a small iron anvil with a taper shank protruding from its base so as to stand firm in a tapered hole in the work block. Incidentally, some of the old hands to this day refer to working "at the block." (2) A small hammer, varying in size according to the size of needles to be made. (3) A leaden block about 4 in. cube. (4) Punches with which to make the eyes: one with a sharp but short point to indent the wire where the eye was to be, and the other a long taper punch with a fine point, to make the eye. (5) A small pair of tongs with a groove in each jaw, running lengthways, to hold the needle. (6) The guttering iron, which was a tool shaped like a small butcher's cleaver, having teeth along its edge. (7) A small flat file. (8) A piece of boxwood, held by a staple driven into the edge of the block.

The wire, which was of iron, was cut to the length of a needle, placed in the tongs lengthways, held on the boxwood block and the point filed upon it. The plain end of the pointed wire was then placed upon the anvil and flattened with the hammer. Then, with the blunt punch, an indentation was made in the flattened end by striking the punch lightly; this was the first process in making the eye. The wire was then transferred to the leaden block, where the long taper punch was driven right through the flattened part, previously indented. The wire was taken off the punch, which was driven in again, from the opposite side. The wire, with the punch still in, was placed upon the anvil, and a light blow was given on the sides of the eye to beat back the slight bulging which had taken place. The needle was then taken in the tongs again, the hasp closed and the guttering iron was brought into use. This tool was nothing more than a heavy file, and was used to make a groove on each side between the eye and the end of the needle, for the thread to lie in. Still in the tongs, the needle was placed on the boxwood block and the head trimmed up and filed into shape. The needle was then "made." There still remained the hardening and polishing to be done.

As previously stated, the wire from which the needles were made was of iron. The process of conversion into steel was called by the needlers "pyeing." Rectangular cast-iron pots were used, into which the needles were packed with bone dust, after which they were subjected to heat in an open fire until they were "pyed." They were then hardened in water and tempered. The water hardening caused many of the needles to bend, and women, called hammer straighteners, were employed to straighten them. They placed each needle separately upon a flat piece of iron and rolled it with their fingers to see where it was bent, and then straightened it with a hammer.

Polishing, called "scouring," was done by placing from twenty to thirty thousand needles in a canvas packet, made up with several layers of canvas, and tied with cord. With the needles was placed an abrasive, together with soap. These packets, about 4 or 5 in. in diameter and about 2 ft. 6 in. long, were placed in the scouring machine, which consisted of a stationary wooden bed, upon which reciprocated a thick flat slab of wood, weighted with iron. The packet of needles was placed upon the fixed bed and, after being rolled to and fro for many hours under the moving slab, the needles were taken out, washed in hot suds and dried in sawdust in a tub rolled on the floor by hand. The needles were then finished.

The scouring machine was generally situated upon a stream, where it could be driven by water power. Several of these old needle scouring mills are to be seen in the Redditch district at the present time.

* Paper presented to the Newcomen Society, January 15, 1941. Abridged.

INSTITUTION ELECTIONS.

INSTITUTION OF CIVIL ENGINEERS.

Associate Member to Member.—Ronald Wilfrid Bateman, B.Sc. (Eng.) (*Lond.*), Egypt; Sir Arrol Moir, Bart., B.A. (*Cantab.*), London, S.W.1.

Associate Member.—Stanley Raymond Chetwynd Archer, B.Sc. (*Glas.*), Glasgow; Iain Mackintosh Bain, B.Sc. (*Edin.*), Kirkaldy; Thomas Archibald Campbell Brownlie, B.Sc. (*Edin.*), Lahore; Rupert Arthur George Eveleigh, B.Sc. (Eng.) (*Lond.*), Maghull; John Angus Fox, Aberdeen; John Hayes, B.Sc. (*Manch.*) West Drayton; Stanley Edward Jewkes, Sedgley; Michael Vivian Keelan, B.Sc. (Eng.) (*Lond.*), Hendon; John Thomas Lewis, Chester; George Charles Minder, B.Sc. (*Bristol*), Bristol; Gerald Ernest Marshall, B.Sc. (*Durham*), Sunderland; Robert Brownlee Masterton, B.Sc. (*Edin.*), Edinburgh; Henry Olivier, B.Sc. (*Cape Town*), Bexley; Raymond Pownall, B.A. (*Cantab.*), Manchester; Kenneth Poyton, B.Sc. (Eng.) (*Lond.*), London, E.5; John Hartley Roberts, B.Sc. (Eng.) (*Lond.*), Tynemouth.

ASSOCIATION OF CONSULTING ENGINEERS.

Member.—Ernest Griffiths, M.I.Mech.E., M.I.H.V.E., M.R.San.I., and Evelyn Edward Griffiths, M.I.Mech.E., M.I.H.V.E. (Ernest Griffiths and Son), Bromborough; Harry Peretz Kaufman, B.Sc. (Eng.) (*Lond.*), M.Inst. C.E., A.M.I.Struct.E. (G. P. Kershaw and Kaufman), High Wycombe; Robert Nelson, M.I.E.E., M.I.Min.E., London, S.W.1; Charles William Smith, M.I.E.E. (Handcock and Dykes), London, S.W.1; John James Crosbie Paterson, C.I.E., M.Inst.C.E., M.I.Mech.E., M.I.Loco.E., Richard Lionel Ray, M.I.Mech.E., John Matthew Blackwood Stuart, C.I.E., B.A., B.A.I. (*Dublin*), M.Inst.C.E., and Julian Seymour Tritton, M.Inst.C.E., M.I.Mech.E., M.I.Loco.E. (Rendel, Palmer and Tritton), London, S.W.1; Alec George Vaughan-Lee, M.Inst.C.E. (Coode, Wilson, Vaughan-Lee and Gwyther), London, S.W.1.

INSTITUTION OF STRUCTURAL ENGINEERS.

Associate Member to Member.—Harry Thomas Avey, Greenford.

Associate.—Cecil Ernest Millard Fillmore, F.R.I.B.A., Birmingham; John Watt, Huddersfield.

Associate Member.—Royden Hibbert Newman, Napier, New Zealand; George William Spooner, Swansea; William Stanley Yates, Liverpool.

Graduate to Associate Member.—Arthur John Bond, Warrington.

THE LATE MR. J. W. HAMPSHEIR.—We note with regret the sudden death, on January 8, of Mr. John White Hampsheir, a director and general manager of Messrs. Keith, Blackman, Limited, engineers, Mill Mead-road, Tottenham, London, N.17. Mr. Hampsheir joined Messrs. Keith, Blackman's clerical department in 1892, became secretary in 1905, and was elected to the board of directors in 1921. In 1925, he was appointed general manager. He was 71 years of age.

APPEAL FOR OLD TRACING LINEN.—The Director of the Building Centre, 158, New Bond-street, London, W.1, informs us that the appeal for old linen tracings, made by him some time ago, was attended with gratifying results and that hundreds of articles, including surgeons' caps and masks, bandages, pillow cases and aprons have been made with the material by the Women's Voluntary Services. The demand from the various branches of this organisation, however, is still very great and the Director of the Centre is making a fresh appeal to engineering and other technical firms to send him, at the above address, bundles of old linen tracings for which they have no further use. He states that every care will be taken to see that the material is utilised for no other purpose than that for which it has been asked.

AIR-RAID PRECAUTIONS NEWS SERVICE.—The Editor of the monthly journal *A.R.P. News* informs us that he is inaugurating a confidential news service for the information of Civil Defence executive officers. The object is to place in the hands of these officers, who can use the information to the advantage of the public, facts which cannot be given open publication. The information will be forwarded by sealed-letter post so that detailed technical reports of improvised remedies, etc., will be quickly available to suggest measures which may be promptly taken by the recipients. The service will be available only to such officers as city engineers, chief wardens, medical men engaged in A.R.P. work, chiefs of the Auxiliary Fire Service, and others who can use the service to advantage and be vouched for by responsible officials. Persons wishing to subscribe to the news service should communicate with the Editor, *A.R.P. News*, 19, Mincing-lane, Blackburn, Lancashire.

PERSONAL.

LT.-COL. LORD DUDLEY GORDON, D.S.O., has been nominated for a second year of office as President of the Federation of British Industries. He is chairman of Messrs. J. and E. Hall, Limited, Dartford, Kent, and a former president of the British Engineers' Association.

MAJOR PERCY LEWIS JONES, M.C., M.Inst.C.E., M.I.Mech.E., general manager, Engineering Department, Messrs. Swan, Hunter, and Wigham Richardson, Limited, Neptune Works, Walker, Newcastle-upon-Tyne, 6, has been re-elected chairman of the North-Eastern Branch of the Institution of Mechanical Engineers.

MESSRS. THE GENERAL ELECTRIC COMPANY, LIMITED, Magnet House, Kingsway, London, W.C.2, have opened new branch offices at Lawford-street, Old Market, Bristol, 2.

MR. G. W. LOWES has retired from the position of manager of the Rolling-Mill Department of Messrs. Skinningrove Iron Company, Limited, after occupying the appointment for 27 years. He has been succeeded by the assistant manager, MR. C. W. CAMERON.

MR. HENRY MARK PEASE has been elected President of the International Standard Electric Corporation, New York. He was elected to the board of the Western Electric Company, Limited in 1913 and was managing director of this company and of Standard Telephone & Cables, Limited, Connaught House, Aldwych, London, W.C.2, from 1919 until 1928. In 1927 he was given the additional appointment of vice-president and European general manager of the International Standard Electric Corporation, and, in 1933, was appointed executive vice-president of the Corporation.

MR. HORACE BOOT, M.Inst.C.E. (Messrs. Horace Boot and Partners, Limited), whose election to the office of Sheriff of the City of London we recorded last week, informs us that his address for all communications is now Clarefield Court, Pinkney's Green, Maidenhead, Berkshire. (Telephone, Maidenhead 243.)

MESSRS. BROADWAY ENGINEERING COMPANY, LIMITED, Carlisle-road, Hendon, London, N.W.9, have recently concluded agreements with Criterion Machine Works, Los Angeles; Bakewell Manufacturing Company, Los Angeles; Hunter Engineering Company, Riverside (California); and Rex Products, Detroit, U.S.A., under which they have sole rights, for Great Britain, in dealing with the products of these companies.

TENDERS.

WE have received from the Department of Overseas Trade, Millbank, London, S.W.1, particulars of the undermentioned tenders, the closing dates of which are as stated. Details may be obtained at the above address, quoting the reference numbers given.

Taper Pins, solid, steel, machined, and split, flat cotters. South African Railways and Harbours, Johannesburg; February 6. (T. 15,033/41.)

Low-Voltage Switchboards, ten, 3-panel. City Council of Pretoria; February 17. (T. 15,067/41.)

Motor Chassis, three-ton, four-wheeled. South African Railways and Harbours, Johannesburg; March 3. (T. 15,068/41.)

Electric Cooking Apparatus, comprising two hot-water cylinders, two 3-plate domestic stoves, one double-oven range with boiling top, two boilers and coffee machines, one 10 cub.-ft. refrigerator, food-preparation machines and other equipment, for the new General Post Office, Cape Town. Union Tender and Supplies Board, Pretoria; February 20. (T. 15,032/41.)

Telephone Cable, of various types. Post and Telegraph Department, Wellington, N.Z.; February 4. (T. 15,054/41.)

HAMILTON BLAST FURNACE OF AMERICAN ROLLING MILL COMPANY.—The No. 2 blast-furnace, at Hamilton, Ohio, U.S.A., of the American Rolling Mill Company, Middletown, Ohio, has been completely rebuilt and its daily output capacity increased from 350 tons to 700 tons.

CONTROL OF MACHINE TOOLS (NO. 7) ORDER.—The Minister of Supply, in exercise of the powers conferred upon him by Regulations 55 and 98 of the Defence (General) Regulations, 1939, has ordered that the provisions of the Control of Machine Tools (No. 3) and (No. 4) Orders, 1940, shall not apply to sales, or agreements and offers for sale, of used machine tools, by auction. A new Order, entitled the Control of Machine Tools (No. 7) Order, 1940, directs that no person shall sell, or agree or offer to sell, any used machine tools by auction, except under the authority of, and in accordance with, a licence or direction issued by, the Minister of Supply. Copies of the Order, which came into force on December 31, 1940, may be obtained, price 1*d.* net, from H.M. Stationery Office, York House, Kingsway, London, W.C.2.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—The demand for steel material of all kinds is still pressing. Ship and boiler plates, sections, etc., are urgently needed, but the organisation now operating is such that all users are being kept supplied. There is a very strong demand for black and galvanised sheets, so that stocks are very low. All works are operating at full capacity and, as ample stocks of raw materials are held at most establishments, the outlook is quite satisfactory. The following are the present quotations:—Boiler plates, 17*l.* 12*s.* 6*d.* per ton; ship plates, 16*l.* 3*s.* per ton; sections, 15*l.* 8*s.* per ton; medium plates, ¼ in. and thicker, rolled in sheet mills, 21*l.* 15*s.* per ton; black-steel sheets, No. 24 gauge, 22*l.* 15*s.* per ton; and galvanised corrugated sheets, No. 24 gauge, 26*l.* 2*s.* 6*d.* per ton, all for home delivery.

Malleable-Iron Trade.—There has been little change in the state of the malleable-iron trade during the past week and makers are fully occupied. Order books generally are well filled and the prospects are considered to be satisfactory. The re-rollers of steel bars are operating at full capacity and orders have to be treated in strict rotation. Bookings cover the output well ahead but as the supply of semi-manufactured material has recently been accumulating, the forward position is assured for some time. The current quotations are as follows:—Crown bars, 15*l.* 12*s.* 6*d.* per ton; No. 3 bars, 13*l.* 12*s.* 6*d.* per ton; No. 4 bars, 13*l.* 17*s.* 6*d.* per ton; and re-rolled steel bars, 17*l.* 15*s.* per ton, all for home delivery.

Scottish Pig-Iron Trade.—As in the other branches of industry, the Scottish pig-iron trade is operating at maximum capacity. Although the demand is on an exceptionally large scale, makers are managing to give consumers satisfactory deliveries. Steelmakers are pressing for deliveries of both hematite and basic iron and the large output is only just sufficient to meet requirements. Foundry grades of iron are not in such heavy demand but plenty of business is passing. Fairly good supplies of raw materials are now held. Prices are unchanged and are as follows:—Hematite, 6*l.* 18*s.* 6*d.* per ton, and basic iron, 6*l.* 0*s.* 6*d.* per ton, both delivered at the steel works; foundry iron, No. 1, 6*l.* 5*s.* 6*d.* per ton, and No. 3, 6*l.* 3*s.* per ton, both on trucks at makers' yards.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Welsh Coal Trade.—The Great Western Railway Company's reply to criticisms that have been made regarding the congestion that has taken place in coal traffic from the western part of the coalfield was made during the past week by Sir James Milne, general manager of the Company. He pointed out that strenuous efforts had been made to increase the district's share of the inland coal trade, but the Company had been unable to deal with all the extra traffic offered. It had to be borne in mind that the railway lines in South Wales were laid out to deal with a large export trade, but on the collapse of France a considerable quantity of coal was immobilised at the South Wales docks and the colliery companies and the Mines Department had co-operated to reduce this accumulation of stocks although it had adversely affected the amount of coal that could be conveyed from the collieries. Apart from this, the Company was being asked to deal with a greatly increased inland coal traffic at a time when they had to handle a much greater volume of freight train traffic than they did in peace time, and additional transport facilities could not be provided at short notice. The volume of inland coal traffic that could be handled depended to a large extent upon the priority that could be given to the traffic in relation to other essential traffic, but under present conditions there appeared to be little likelihood of the Company being able to accept more coal traffic during the next three months than had been accepted during the corresponding period of last year when, incidentally, the traffic handled was greater than in 1939. It would appear desirable, therefore, that the total quantity of coal that the Company could be expected to handle should be determined and that some machinery should be instituted to ensure that this tonnage was allocated on an equitable basis among the various collieries. There was a sustained demand from home industrial users for the high-volatile bituminous sorts which were not easy to secure for delivery over some time ahead owing to recent heavy sales. There was no shortage of the dry steam coals, however, despite the curtailment that has taken place in production, and a dull tone ruled for these coals. Cokes were in brisk request from home users, but patent fuel remained slow.

The Iron and Steel Trade.—Active conditions ruled in the iron and steel and allied trades of South Wales and Monmouthshire last week. There was a sustained demand for the various finished products but new business was not easy to arrange and works were engaged almost to full capacity.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

General Situation.—The small change in the general state of the iron and allied trades is in the direction that encourages hopes that there will be a gradual increase in the tonnage available for distribution. The supply position is already more favourable than it has been for some time. Reserves of raw materials, of certain descriptions of pig iron and of semi-finished steel have been created, and other commodities are steadily becoming more plentiful. Producers are still concentrating largely on the fulfilment of Government orders, but there are indications of the release of some additional tonnage for other purposes. The total output of iron and steel is maintained at near the record level and with the aid of increasing imports of commodities from the United States, the exceptionally heavy demand will be met satisfactorily.

Cleveland Iron Trade.—The deliveries of foundry iron are still ample for requirements although no appreciable improvement in the limited supply of Cleveland pig can yet be reported. The production of local brands is still intermittent and there is little prospect of an early resumption of the regular make. North-East Coast founders have no difficulty in obtaining adequate supplies of Midland iron for general use and are also receiving, from elsewhere, parcels of certain qualities of pig required for specified purposes. The volume of business passing through second hands is on an improved scale, but is still not extensive. The official values of Cleveland pig remain at the equivalent of No. 3 quality at 128*s.*, delivered within the Tees-side zone.

Hematite.—The heavy make of hematite, together with the supply of American iron, provides only just sufficient tonnage for consumers' requirements, and as the demand continues to increase, larger imports from across the Atlantic are needed. Merchants are handling sufficient tonnage to meet the requirements of their regular customers, but would be glad to increase their transactions. Deliveries, against running contracts, to buyers who are dependent on the market for supplies, are better than has been the case recently, but most of the iron available for delivery is still absorbed by the consuming plants owned by hematite makers. The stabilised quotations of East Coast brands and American hematite remain at the level of No. 1 description at 138*s.* 6*d.*, delivered to North of England areas.

Basic Iron.—There is still no basic iron on sale. Makers, after meeting the requirements of their own steelworks, are retaining the surplus output in order to accumulate stocks. The nominal price of basic iron remains at 120*s.* 6*d.*

Foreign Ore.—Consumers of foreign ore are becoming considerably less dependent on overseas supplies owing to the increasing use of local and other native ironstone.

Blast-Furnace Coke.—There are few transactions in Durham blast-furnace coke. Orders can be placed on the basis of good medium qualities at 35*s.* 6*d.*, f.o.r., but local users are bought as extensively as they consider desirable, and sellers, having good order books, are not pressing business.

Manufactured Iron and Steel.—Ample deliveries of semi-finished iron and steel are keeping the re-rolling mills actively employed. Sheetmakers are running their plant at full capacity, but have some difficulty in meeting the heavy demand. All classes of finished steel are in strong request, the demand for medium and light sections and small bars being especially heavy. The deliveries of plates, angles, etc., are sufficient to enable satisfactory progress to be made with the shipbuilding work in hand. Soft steel billets are quoted at 12*l.* 5*s.* per ton; hard billets at 13*l.* 12*s.* 6*d.* per ton; joists and sections at 15*l.* 8*s.* per ton; heavy plates at 16*l.* 3*s.* per ton; and heavy rails at 14*l.* 10*s.* 6*d.* per ton.

Scrap.—Users of iron and steel scrap are carrying considerable stocks, but continue to accept contract deliveries and are desirous of placing forward orders. For delivery to the North East Coast, heavy steel scrap is 72*s.* 3*d.*, heavy mixed scrap, 70*s.* 3*d.*; bundled steel cuttings, 65*d.* 3*d.*; heavy steel trimmings, 53*s.* 3*d.*; cast-iron borings, 46*s.* 3*d.*; and heavy cast iron, 77*s.* 9*d.*

IRON AND STEEL INDUSTRY OF CANADA.—The production of steel ingots in Canada during the first ten months of 1940 totalled 1,649,639 gross tons and the output of pig iron 948,841 gross tons. The corresponding figures for January-October, 1939, were, respectively, 1,087,583 tons and 573,740 tons.

BRAZILIAN GOVERNMENT RAILWAY ORDERS.—The Ministry of Transportation and Public Works, Brazil, has recently placed orders with United States manufacturers for 450 thirty-ton freight railway wagons of various types, 8 thirty-ton tank wagons, and 150 sets of bogies for 20-ton freight wagons.

NOTICES OF MEETINGS.

IT is requested that particulars for insertion in this column shall reach the Editor not later than Tuesday morning in the week preceding the date of the meeting.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—To-night, 6 p.m., The Mining Institute, Newcastle-upon-Tyne. Lecture: "Optical Instruments: Particularly Large Astronomical Telescopes," by Mr. G. E. Manville.

INSTITUTION OF ELECTRICAL ENGINEERS.—*North Midland Students' Section:* Saturday, January 18, 2.30 p.m., The Hotel Metropole, King-street, Leeds. "Application of Electricity to Railway Signalling," Mr. G. G. F. Halliwell.

ROYAL SOCIETY OF ARTS.—Monday, January 20, 1.45 p.m., John Adam-street, Adelphi, W.C.2. Cantor Lecture I. "Some Problems of World Economic Development," by Sir David Chadwick. Wednesday, January 22, 1.45 p.m. "Flight Re-Fuelling," by Sir Alan Cobham. Friday, January 24, 1.45 p.m. "Recent Labour Legislation in India," by Sir Frank Noyce.

INSTITUTION OF CIVIL ENGINEERS.—Tuesday, January 21, 1.30 p.m., Great George-street, Westminster, S.W.1. Ordinary Meeting. "The Design of Sewage-Purification Works," by Mr. H. C. Whitehead.

INSTITUTION OF MECHANICAL ENGINEERS.—Friday, January 24, 2 p.m., Storey's-gate, St. James's Park, S.W.1. Special Meeting for the Presentation of the James Watt International Medal to Professor Dr. Aurel Stodola. 2.30 p.m., General Meeting. Thomas Lowe Gray Lecture: "Progress in Marine Engineering as Influenced by the Classification of Ships," by Dr. S. F. Dorey.

JUNIOR INSTITUTION OF ENGINEERS.—Saturday, January 25, 1.30 p.m., 39, Victoria-street, Westminster, S.W.1. Ordinary Meeting. "Protective Coatings on Metals," by Mr. P. A. Cartwright.

INSTITUTION OF AUTOMOBILE ENGINEERS.—*Luton Centre:* Saturday, January 25, 2.45 p.m., The George Hotel, Luton. "Producer Gas for Road Vehicles," by Mr. Maurice Platt.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—Trade conditions generally show no marked change. The works are maintaining high outputs of all types of products including machinery, high-efficiency steels, and tools. The raw and semi-finished steel-making branches are operating at full capacity, and have more furnaces in commission than at any time during the past six months. That production is increasing is indicated by the larger purchases which steel producers are making of hematites, pig iron, and scrap. No difficulty is being experienced in obtaining adequate supplies. Makers of high-efficiency steels are exceptionally busy; the use of high-frequency furnaces is extending and more plant is being put down at several works. The heavy machinery and engineering branches are operating at full capacity, and rolling mills, forges, press shops, foundries, and wire and rod mills are all busily employed. There is a strong demand for grinding and crushing machinery and related equipment, and also a good market for cement and concrete mixing plant. Steelworks machinery is an active line, and rolling mills, forges, hydraulic presses, electric and steam cranes, drilling machines, and lathes are progressive media. The tool trades continue to account for increased outputs.

South Yorkshire Coal Trade.—All classes of fuel are in better demand. Industrial concerns are taking increased supplies, and steam coal is an active market. Railway companies are ordering larger tonnages of locomotive coal, and the house coal position is highly satisfactory; supplies are ample to cover all immediate needs. Foundry and furnace cokes are steady.

REPORTS ON AUSTRALIAN INDUSTRIES.—H.M. Senior Trade Commissioner at Sydney, New South Wales, has forwarded, to the Department of Overseas Trade, reports issued by the Commonwealth Bureau of Census and Statistics relating to a number of Australian industries. Of these, No. 28 deals with sawmilling; No. 29 with rope and cordage; No. 30 with rubber works; No. 31 with brooms and brushes; No. 32 with electric light and power works; and No. 33 with gasworks. The reports give detailed information, for the years 1938 and 1939, regarding the articles produced and the materials used, employment statistics, wage rates, and imports and exports. One copy only of each report is available, on loan, from the Department, 99-103, St. Michael's-road, Bournemouth, Hants. The reference number, 22,133/40, should be quoted in all communications.

NORRIS DAM ON THE CLINCH RIVER, TENNESSEE, U.S.A.

(*For Description, see page* 41.)

FIG. 25. CEMENT TRAILERS DELIVERING TO MIXING PLANT.

FIG. 26. CONSOLIDATING CONCRETE BY VIBRATORS.

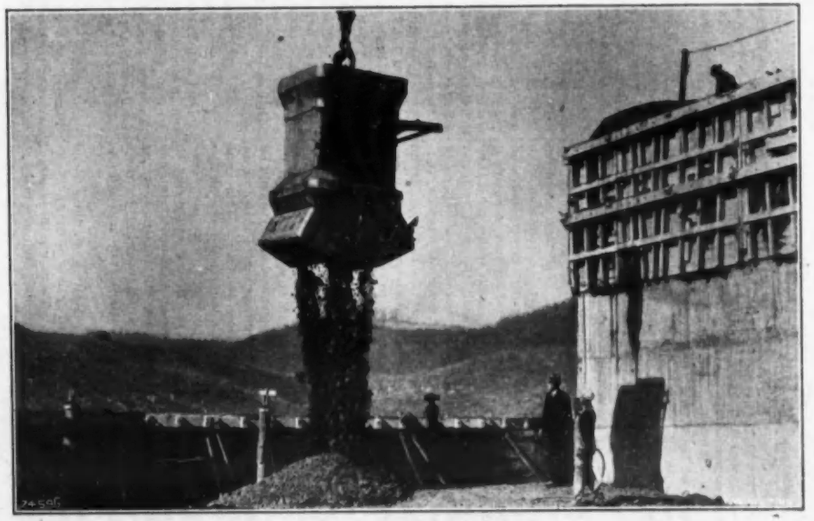


FIG. 27. 6-CUB.-YD. CONCRETE-DUMPING BUCKET DISCHARGING.

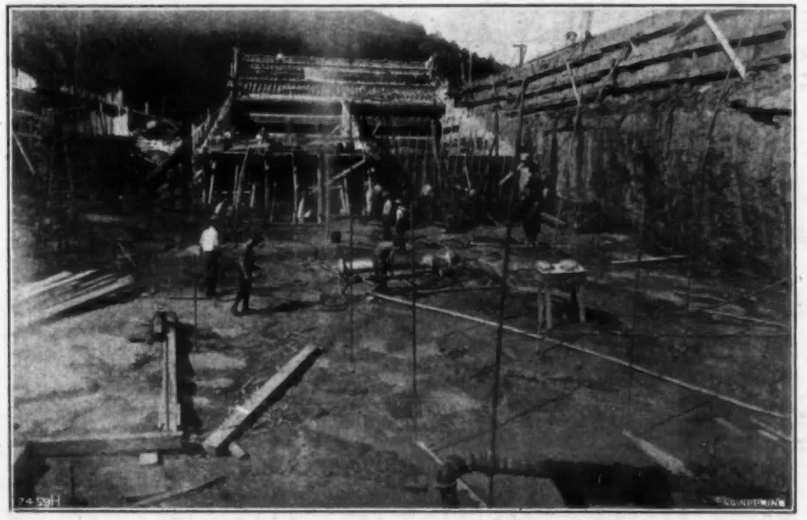


FIG. 28. WASHING OUT BOREHOLES BEFORE GROUTING.

THE NORRIS DAM ON THE CINCH

(For Descri... see page 4

FIG. 21. GENERAL VIEW OF QUARRY AND SCREENING PLANT.

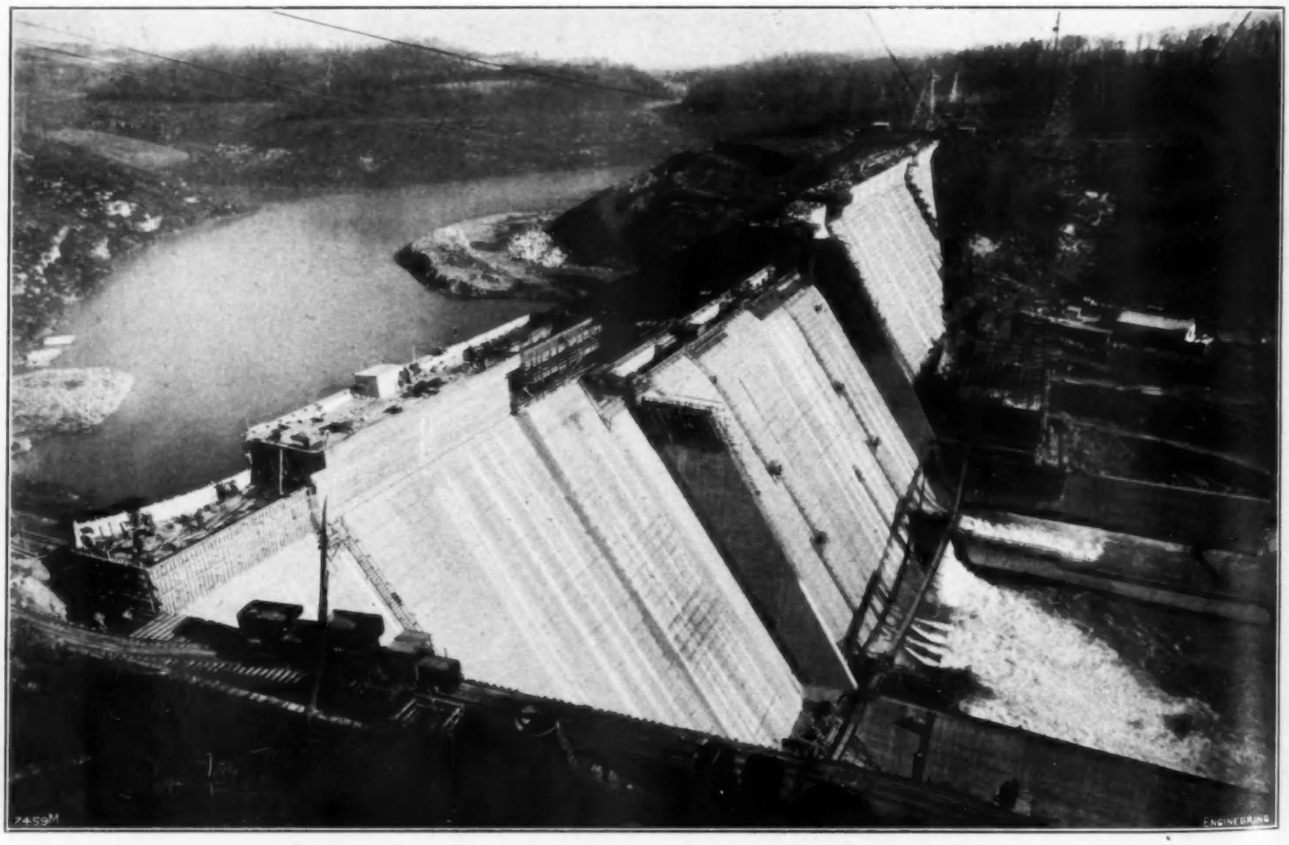


FIG. 23. PARTIALLY COMPLETED DAM, SHOWING CHAMBERS IN CREST FOR DRUM GATES.

CINCH RIVER, TENNESSEE, U.S.A.

(Description on page 41.)

FIG. 22. AGGREGATE PLANT ON THE SOUTH SIDE OF THE GULLEY.

FIG. 24. COMPLETED DAM SHOWING QUARRY ON LEFT.

UNIV. OF MICH.

ENGINEERING.

Offices for Publication and Advertisements, 35 & 36, Bedford Street, Strand, London, W.C.2.

We desire to call the attention of our readers to the fact that the above is the address of our Registered Offices, and that no connection exists between this Journal and other publications bearing somewhat similar titles.

TELEGRAPHIC ADDRESS { "ENGINEERING," LESQUARE LONDON.

TELEPHONE NUMBER—TEMPLE BAR 3663 (2 lines).

SUBSCRIPTIONS, HOME AND FOREIGN.

"ENGINEERING" may be ordered from any newsagent in town and country and at railway bookstalls, or it can be supplied by the Publisher, post free, at the following rates, for twelve months (or for six or three months, *pro rata*), payable in advance :—

For the United Kingdom	£3 5 0
For Canada—	
Thin paper copies	£2 18 6
Thick paper copies	£3 3 0
For all other places abroad—	
Thin paper copies	£3 3 0
Thick paper copies	£3 7 6

Foreign and Colonial subscribers receiving incomplete copies through newsagents are requested to communicate the fact to the Publisher, together with the agent's name and address.

When foreign subscriptions are sent by Post Office Orders, advice should be sent to the Publisher.

ADVERTISEMENT RATES.

The charge for advertisements classified under the Headings of Appointments Open, Situations Wanted, Tenders, &c., is four shillings for the first four lines, or under, and one shilling per line up to one inch. The line averages six words. When an advertisement measures an inch or more the charge is 12*s.* per inch. Payment must accompany all orders for single advertisements, otherwise their insertion cannot be guaranteed. Terms for displayed advertisements on the wrapper and on the inside pages may be obtained on application. The pages are 12 in. deep and 9 in. wide, divisible into four columns, of 2¼ in. in width. Serial advertisements will be inserted with all practicable regularity, but cannot be guaranteed.

TIME FOR RECEIPT OF ADVERTISEMENTS.

Classified advertisements intended for insertion in the current week's issue must be delivered not later than first post on Wednesday. Alterations to standing advertisements must be received at least 10 days previous to the day of publication. Passed proofs must be in our hands by Saturday morning, otherwise they will be taken as correct. The Proprietors will not hold themselves responsible for blocks left in their possession for more than two years.

All accounts are payable to "ENGINEERING," Ltd. Cheques should be crossed "The National Provincial Bank, Limited, Charing Cross Branch." Post Office Orders should be made payable at Bedford Street, Strand, W.C.2.

TEMPORARY ADDRESS.

For the duration of hostilities, the Editorial and Publishing business of this Journal is being conducted from 18 and 20, Compton Road, Hayes, Middlesex. The Telephone Number of the Editorial Department is Hayes 1730, and that of the Publishing Department, Hayes 1723. The Bedford Street Offices are open on Fridays only, between 10 a.m. and 5 p.m., for the distribution of the current issue and for retail sales.

CONTENTS.

	PAGE
Dam Construction in the Tennessee Valley (*Illus.*)	41
The Engineering Outlook—I	44
Voltage-Operated Earth-Leakage Protection	45
The Edgwick Optical Dividing Head (*Illus.*)	46
Gun-Barrel Spline-Shaping Machine (*Illus.*)	47
Early Needle Making	48
Institution Elections	48
Personal	48
Tenders	48
Notes from the North	49
Notes from the South-West	49
Notes from Cleveland and the Northern Counties	49
Notices of Meetings	49
Notes from South Yorkshire	49
The Position of British Shipping	51
Safety First	52
Notes	53
Letters to the Editor.—The Failure of the Tacoma Narrows Bridge. Concrete for Buildings	54
Obituary.—Professor D. Robertson. Mr. T. W. K. Clarke	54
Temperature Measurement in Moving Machinery	55
14-Ton Welded Railway Wagon (*Illus.*)	56
Notes on New Books	56
Labour Notes	57
Mechanical Gearing for Large Power Transmission (*Illus.*)	57
Canadian Standard Specifications	60
"ENGINEERING" Patent Record (*Illus.*)	60

One Two-Page Plate.—THE NORRIS DAM ON THE CLINCH RIVER, TENNESSEE, U.S.A.

ENGINEERING

FRIDAY, JANUARY 17, 1941.

VOL. 151. No. 3914.

THE POSITION OF BRITISH SHIPPING.

THE announcement by the Admiralty of the shipping losses for the week ended January 6 is cheering, in spite of official warnings that too much weight should not be attached to a result which may have been exceptionally influenced by any of several possible causes. Whether or not this official caution is inspired by knowledge that those for the following week are likely to be heavier, it is permissible to enjoy all the satisfaction that can be extracted from the fact that, during the week indicated, the losses comprised only four British ships, totalling no more than 14,687 tons; and that there were no Allied or neutral losses at all. This figure, it is stated, is the lowest for eight months, and the fifth lowest since the beginning of the war. It comes as a pleasant relief after the heavy sinkings of December, which amounted to 64 ships, aggregating some 268,000 tons, almost exactly one-tenth of the British losses in tonnage and number of ships, from all causes, since the outbreak of hostilities.

It is not to be supposed that the weekly toll can be maintained at so moderate a figure as less than 15,000 tons, though it should be practicable to reduce the average—at present about 62,500 tons a week since the beginning of the war—to a figure approximately balanced by the rate of accession of new and purchased tonnage. What this combined rate may be can only be guessed, in the absence of statistics of new construction, which are not likely to be disclosed; but it is reasonable to assume that the better protection to convoys, rendered possible by the advent of the 50 ex-American destroyers and by the completion of the destroyers, the new "corvettes" and other light craft designed for escort duties, will exert a considerable influence on the rate of sinkings. If, in addition, the optimism expressed by Admiral Cunningham, commanding the naval forces in the Mediterranean, regarding the possible source of events in that sea, are justified by the outcome of the present operations against Italy, this also should be reflected in the curve of shipping losses. The recent report of the action between the cruiser Southampton, the aircraft-carrier Illustrious and the destroyer Gallant, and two Italian destroyers supported by German and Italian aircraft, afforded evidence that convoys are still passing through the Mediterranean; but earlier announcements in connection with the operations of General Wavell's army in the Western Desert disclosed that much of the work of supplying that army has been effected via the Cape, and it requires no intimate knowledge of sea transport to realise that this greatly extended passage represents, in effect, an appreciable reduction in the volume of tonnage available for service elsewhere. The avoidance of this necessity will represent an equally significant relief to the shipping position.

It will become increasingly important in the near future to take the fullest advantage of operational benefits such as this, and of any others that can be contrived by reducing the amount of non-productive voyaging and the time occupied in ports, because the remaining reserves of tonnage on which the Allied mercantile marine can draw are now so diminished as to be of little account. Practically the whole of the European-owned tonnage is now either sunk, or is under the control of Britain or Germany. The Spanish shipping which used to trade so extensively with British ports is virtually out of the reckoning to-day; and Japanese tonnage, which was of material assistance in the last war, is so no longer. A certain number of enemy ships remain interned in neutral ports, and rumours are current of attempts to obtain their release in the Allied interest; but this source is hardly one that can be counted upon to any extent. There is little doubt that many neutral countries, if not most of them, would regard such an arrangement favourably if it could be negotiated with due regard to the preservation of technical neutrality; if only because the accumulated arrears of dock and harbour dues on these vessels must represent an appreciable amount of revenue, the settlement of which by the British Government would, presumably, be an essential part of the agreement for release of the ships. Whether the German crews would acquiesce in any such bargain, however, is another matter. The history of the last war suggests that they would be more likely to render the ships unserviceable before they could be moved; and for this reason no extensive relief can be expected from this theoretical reserve of tonnage.

There are other reserves, not dependent upon neutral goodwill or the prevention of German sabotage, which, nevertheless, should hardly be reckoned in calculations of the gross tonnage available; for example, vessels engaged in local services and unsuited by their design for general employment at sea. Vessels damaged but not sunk, and those detained in port for necessary voyage repairs, do not figure in the returns. The delays due to steaming at less than normal speed, and the extension of peace-time port-to-port distances by frequent alterations of course—both unavoidable features of convoy work—are other instances of operational difficulties which, in practice, render any aggregate figures of nominally available tonnage somewhat illusory as guides to the true shipping position. In peace, a yearly average of 200 days at sea was considered a fair performance for an ordinary cargo steamer. Reducing the war-time performance to its equivalent in normal peace-time steaming, it may be questioned whether, in effect, the same vessel is engaged in actual transport for more than half of this period.

It appears, therefore, that one of the principal remaining means of increasing the availability of tonnage is by reducing the time spent in port. An important step in this direction has been taken by the Ministry of Transport during the past week, in the appointment of Mr. J. Gibson Jarvie, chairman of the United Dominions Trust, Limited, and Mr. Robert Letch, assistant general manager of the Port of London Authority, to be regional port directors for the North-Western Region and the Clyde Region, respectively. The former region comprises all ports between Holyhead and Silloth and the latter, the ports between Stranraer and Oban; and in these districts the new directors are empowered to issue to the individual port emergency committees the instructions for regulating traffic which, previously, were issued direct by the Ministry In general terms, the directors are authorised to exercise, on their own responsibility, all the functions

hitherto discharged by the Minister with the object of co-ordinating the activities of the several ports, securing the rapid turn-round of ships, and utilising the available transport facilities to the best advantage. From the point of view of general policy, perhaps the most interesting feature of this new departure is its recognition of the virtues of decentralisation in avoiding delay.

Undue optimism is liable to lead to disappointment, but perhaps the hope may be expressed that the lessons of this change will not be lost on those responsible for the Ministry's policy in controlling the building and subsequent allocation of the ships themselves. It has been a matter of some concern to shipowners that they have not been permitted to purchase ships in replacement of losses incurred in their own fleets, and fears have been expressed by Sir Philip Haldin, president of the Chamber of Shipping of the United Kingdom, that this refusal may indicate influences, within the Ministry of Shipping, which are deliberately working for the eventual nationalisation of the Mercantile Marine. If there is any substance in these suggestions—and it may be assumed that a spokesman of such standing and experience would not make a statement of this kind without some justification—an authoritative declaration on the point by the Government appears to be called for. There is ample evidence in the experience of other nations that shipping is not a suitable industry for such over-centralised control as nationalisation implies, but the advocates of such policies are notoriously difficult to convince. As Sir Philip observed in his presidential address to the Chamber of Shipping in February last,* the Australian Government lost 12,000,000*l.* over their national shipping venture, the Canadian Government lost about 6,000,000*l.* over theirs, and the financial losses incurred by the United States Government "are quite incalculable, but certainly exceed 600,000,000*l.*" The cost of making good the damage done to the mercantile fleets, at the prices which are certain to rule after the war, will be a sufficiently heavy burden for the industry to support, without the wastage involved in acquiring anew the experience for which these countries have already paid so dearly. A purely domestic trade may be able to afford such experiments, but an international trade cannot.

There are two other directions in which opportunity may be found to accelerate the turn-round of ships in British ports, by reducing the amount of work to be done, and increasing the rate at which the unavoidable remainder is carried out. The survey standards imposed by British legislation and by the requirements of the registration societies are probably the highest in the world and have contributed materially to the high quality of British shipping generally, but it may be questioned whether, under stress of war, some relaxation may not be advisable. The requirement that some particular item of equipment must be surveyed at intervals of say, twelve months, does not necessarily mean that, in the thirteenth month, it becomes a source of danger; and such operations as the stripping of insulation and deck coverings, for the periodical examination of the structure beneath could often be postponed without materially increasing a risk which, in any case, is trivial by comparison with the hazards that are inevitable in time of war. A certain amount of latitude in this respect has always been allowed, and, no doubt, full advantage is being taken of it; but it is within the powers of the Ministry to legalise a somewhat greater degree of latitude, the practical interpretation of which could be safely left to the inspecting authorities. The other point, which appears to offer opportunities for time-saving, is the persistence of local trade-union rules and practices, such as questions of demarcation, which have the effect of limiting the effective output of employees in ship-repairing yards. Many of these were originally designed to ensure that the introduction of new methods and appliances should not cause unemployment among skilled operatives. That risk has virtually ceased to exist, but we have some reason to doubt whether the rigidity of local rules has diminished in a corresponding degree.

* See ENGINEERING, vol. 149, page 259 (1940).

SAFETY FIRST.

AT a meeting held on Wednesday, January 8, the National "Safety First" Association changed its name to the Royal Society for the Prevention of Accidents. Although the Association has been carrying on excellent work under the former title for the past twenty-five years, the general secretary, Colonel J. A. A. Pickard, said at the meeting that the original meaning of the expression "safety first" had been distorted in a selfish sense which was entirely inappropriate to the prevailing conditions. The work of the Association was never more necessary than to-day and it was felt that it might be handicapped if it were carried on under a title which, through wrongful interpretation, was felt to be contrary to the present needs and spirit of the country.

We do not know who has been distorting the meaning of the expression "safety first," but we do not know, either, that that meaning has ever been specifically defined. The expression is a slogan and, as Hitler well knows, it is not necessary that a slogan should mean anything very precise. "Safety first" is probably an importation from the United States, a country in which inexactitude in the use of the English language is not altogether unknown. It is unlikely that, in America, "safety first" has been understood to mean what it literally says; certainly it has not in this country. No one familiar with industrial and traffic matters is likely ever to have supposed that what must now be called the Royal Society for the Prevention of Accidents advocated a policy in which safety was put in front of all other considerations. Had it done so, it would presumably have agitated, for instance, for the complete suppression of all road traffic during the black-out period, except such as was concerned with rescue work and fire extinguishing. These latter activities, as they will probably save more lives than they endanger, may clearly still be carried on under a regime in which safety is the primary consideration.

We have no intention of attempting to define what "safety first" really does mean, but some examination of the general attitude of mind which its use indicates may be useful. The intention of those who use the term, and particularly the intention of those who strongly advocate the practice for which it stands, is clearly that proper consideration should be given in all activities to the personal safety of all who are concerned. This is not to say that safety considerations should overrule everything else. We have instanced traffic in the black-out, but endless other examples can easily be found in which safety is actually placed first. If safety is to come before everything, then all-red periods for the traffic lights must be introduced at all road junctions and pedestrians must be forbidden to cross until all vehicles have stopped. In fact, if safety is the paramount consideration, road bridges for foot passengers must be introduced wholesale and their use made compulsory, and all traffic speeds must be cut down to some low figure at which we will not attempt to guess. In other walks of life, the use of toughened or laminated glass would be made compulsory, all carbon monoxide would have to be removed from town gas, all milk would be sterilised and only safety razors would be permitted.

Engineers are familiar with factors of safety, and a reasonable interpretation of what the safety-first protagonists have at the back of their minds is probably best achieved by looking at the matter from the factor-of-safety point of view. We think it would not misinterpret the objects of the Royal Society for the Prevention of Accidents to say that their aim is to ensure, in all industrial and other operations in which they are interested, that a reasonable factor of safety shall be introduced. As a current example, the engagement of new operatives in munition factories may be instanced. These employees, by reason of unfamiliarity with their surroundings, are more likely to suffer accidents in the shops than are experienced workpeople, and it is certainly part of the duty of those responsible for their training to point out the inherent dangers of machine operation, and to attempt to induce habits of proper care. None the less, in the present emergency, the amount of time that can be spared for this type of tuition is limited, and all that can be expected or hoped for is that reasonable attention shall be given to the matter.

It is probable that Colonel Pickard's reference to the distortion, in a selfish sense, of the expression "safety first" had relation to the new conditions introduced into all walks of life by the war. We have suggested that by "safety first" the Association never did mean safety before everything; but it did mean a good deal of safety. Presumably, some have contended that peace-time measures of safety should still be applied in war, and that the risk which the ordinary individual has to face should not be increased. Apart from the impossibility of such an idea, it is clearly bad citizenship. When a nation is at war, its citizens are at war and must be prepared to take their share of the common danger. Recently, they have been told that it is their duty to take a part in fire-detection parties, which, during a raid, may involve their presence on the roof rather than in the cellar. If some have contended that the propaganda of the Safety First Association has taught them that their first care must be for their personal safety, Colonel Pickard may well complain of "wrongful interpretation . . . contrary to the present needs and spirit of the country."

There is another good reason for not attempting to give a specific definition of "safety first," namely, that it cannot be done; neither can a limit be laid down specifying the greater tolerance which may be allowed on any operational factor of safety in war-time as compared with the conditions of peace. There is no more point in taking unnecessary risks in 1941 than there was in 1938, but an increased risk which will aid and speed the war effort may well be tolerated or even encouraged. To take a further example from the munition factories, cases will arise, and have often arisen, in which shops in process of equipment are put into commission long before completion. In one shell factory, in the last war, machines were running on the line before the cement round the holding-down bolts was properly set, and one end of a shop was in full production before the roof glazing was completed at the other. Measures of this kind are not dictated by safety first; and, no doubt, many things were done, and are being done still, of which neither the "Safety First" Association nor the factory inspectorate would approve in normal times. The factor of safety has been lowered, and legitimately so. It is not good patriotism, however, to lower it more than need be. It is not only among the operatives that newcomers to shop conditions are to be found in munition factories, and many who are now responsible for some aspect of production may well learn a great deal from what the Royal Society for the Prevention of Accidents has to tell. From Colonel Pickard's remarks, we feel justified in assuming that what is told at the present time will be expressed in terms of factors of safety fully appropriate to a nation fighting for its existence.

As a final point, perhaps we may suggest that the new name which the Association has chosen for itself is not one of the most happy. "The Royal Society for the Prevention of Accidents" is not only rather cumbersome (it can hardly be typed in a single line on an ordinary business envelope), but it adds yet another to the many bodies in this country the names of which begin with "The Royal Society of" or "The Royal Society for." It has also the disadvantage that it lends itself to no convenient contraction in conversation. The National "Safety First" Association was normally and naturally referred to as "the Safety First Association"; but the Royal Society for the Prevention of Accidents can only be referred to by its full name, possibly dropping the "Royal" in conversation. In the end, no doubt, refuge will be found in initials, and we shall be blessed with the "R.S.F.P.A.," adding one more item to a list which is already a torment. Although slogans have their uses, we would not complain about the dropping of "Safety First"; but had the Society called itself the Accident-Prevention Association, or the Royal Accident-Prevention Association, it would have had a shorter name, distinct from others, with its purpose in the forefront.

NOTES.

THE DEVELOPMENT OF EXPORT TRADE.

THE importance of organised co-operative selling in the development of export trade was urged in an address delivered by Mr. L. G. Adams to the Institute of Export, on Wednesday, January 8. He said that the intense competition brought about as the result of the last war, coupled with the extensive development of secondary industries now taking place owing to the present war, meant that if our export trade was to survive careful study must be given to every possible method that could help us to capture and retain the overseas markets. Co-operative selling meant the banding together of four or five firms selling similar, but non-competitive, articles to the same class of buyer. At the head of the group would be a qualified export executive, who would co-ordinate selling policy. The representative abroad would be the employee of the group. As the goods sold by the group would be to the same buyer it would be possible to share equally costs of market research, advertising and propaganda, and where necessary that of show-rooms in the more important markets. Thus it would be possible for the average manufacturer to have an efficient export organisation with almost world-wide ramifications at a fraction of the normal cost. Many manufacturers, Mr. Adams concluded, were now looking to Government export groups for expert guidance. There were in these groups thousands of manufacturers who, if organised on co-operative lines, could play a very important part in the future development of export trade. Export selling would mean more than assisting the war effort; it would lay the foundation for post-war reconstruction and provide employment after the war for many who would otherwise be out of work. Each sale abroad, moreover, would add to the prestige of this country.

THE ORGANISATION OF THE CEMENT INDUSTRY.

Lord Reith, the Minister of Works and Buildings, has appointed a Committee to consider and report, bearing in mind all probable demands for cement in meeting current needs and in post-war reconstruction, and taking into consideration economic strategic and other factors affecting the allocation of cement, whether new cement works should be established, existing ones extended, or old plant modernised; and if so, what general considerations, financial, geographical and economic, should apply. The chairman of the committee is Mr. George Balfour, M.P., chairman of Messrs. Balfour, Beatty and Company, and the members are Mr. R. Bullock, of the National Union of General and Municipal Workers; Major F. C. Cook, chief engineer, Highways Division, Ministry of Transport; Mr. R. Coppock, general secretary, National Federation of Building Trade Operatives; Mr. A. Deakin, acting general secretary, Transport and General Workers Union; Mr. J. S. Holmes, M.P., vice-president, Building Societies' Association; Sir William McLintock, Messrs. Thomson, McLintock and Company, chartered accountants; Mr. George Parker, Messrs. George Parker and Sons, Limited, building contractors; and Mr. P. E. Thomas, past-president of the Royal Institute of British Architects. The secretary is Mr. C. I. C. Bosanquet, Lambeth Bridge House, London, S.E.1.

AIR RAIDS AND ELECTRIC TRACTION.

The Southern Railway's practice of utilising low tension direct-current for traction purposes even on its main lines seems to have been justified by the experience obtained during recent air raids. According to the *Railway Gazette*, the installation of mercury-arc rectifiers in single-unit substations has proved very advantageous. In particular, the inherent overload capacity and general flexibility of such a system has enabled "feeding through" to be carried out more quickly, and with less drop in track capacity, when a substation is put out of action, than would have been possible with more widely spaced multiple-unit substations. In no case, in fact, has damage to a substation, however serious, resulted in suspension of traffic. Moreover, the comparative smallness of a complete single-unit rectifier substation gives it a greater chance of escaping bombing than the much larger buildings necessary to house a number of converter units. The commonest causes of interference with traffic are stated to have been damaged supervisory-control equipment and high-tension feeder cables, but, fortunately, the rejointing of breaks is usually the easiest of the tasks of the electrical squads. It is interesting to learn that though the outdoor switchgear and transforming equipment have been frequently damaged severely, the main indoor apparatus has been more or less undamaged. Further limitation of damage appears to have been effected, in several instances, by the practice of having the direct-current breakers and other low-tension switchgear in annexes separated from the main rectifier room. The value of the remote supervisory control used by the Southern Railway should be stressed. It is true that the repair of the control cables has given much work to the maintenance staff, but all the rectifier substations are normally unattended and this also has probably prevented some loss of life. In other directions a good deal of ingenuity has been displayed in keeping the current on. Another advantage of electric working appeared when a bomb pierced the top boom of a large-span single-line bridge, which was used almost entirely by electric suburban trains. Measurements showed that, although the structure was so weakened as to prohibit the passage of heavy steam locomotives, it could still carry multiple-unit trains at reduced speed owing to their comparatively light axle loads.

NEW BRITISH AIRCRAFT.

A short time ago an American semi-technical journal published details of two new British types of aircraft. This, it is understood, caused some consternation at the Air Ministry on the grounds that it was giving useful information to the enemy. Moreover, it disturbed the British Press, who felt that they had been unfairly treated by the failure to give them similar information. This may explain why details regarding these machines have now been released and are contained in an official statement issued last Saturday. The first machine is a Hawker Tornado single-seated fighter, which has been designed by Mr. S. Camm. Its performance, it is stated, has exceeded the hopes of its designers and it promises to be one of the most efficient and deadly fighter aircraft in the world. It is equipped with a Rolls-Royce Vulture engine, which is at present giving 1,750 h.p., though this may eventually be increased to 2,000 h.p. Performance figures are at present secret, but it was stated by the American writer already referred to that the maximum speed is 425 m.p.h. and that the armament consists of 14 to 16 machine guns or alternative cannon armament. The other machine is the Short Stirling, which is claimed to be the largest bombing aeroplane yet standardised in service. It has four engines with a total output of more than 5,500 h.p. and is capable of carrying a very large bomb load to the most distant objective. According to an American writer, the Stirling is faster than the Boeing "Flying Fortress." A third aeroplane, which is now being used by the Royal Air Force, is the United States Grumman G 36. This is a mid-wing monoplane with a span of 38 ft. 1 in., is equipped with a 1,300-h.p. engine and is capable of a maximum speed of 330 m.p.h. An interesting feature is the electrically-controlled Curtiss airscrew. This machine, it is understood, was designed as a ship fighter.

STANDARDISATION IN THE BUILDING INDUSTRY.

The newly-appointed Director of Standardisation in the Ministry of Works and Buildings (Mr. T. S. Tait), recently explained to a conference of Press representatives that his duty would be to standardise building materials for war-time purposes and to find substitutes for materials which are scarce or likely to be scarce. In this way, it was hoped, manufacturing output would be increased by limiting the number of types and sizes produced, while the work of specifying, designing, ordering and erection would be reduced. Mr. Tait explained that he would work in co-operation with the Directors of Bricks and Roofing Materials, as well as with the officials concerned with economy of timber and steel. The Director of Design (Construction) was also closely concerned, as he dealt with the actual proposals of the Departments and particularly, at the moment, with steel and concrete design. Finally, he would consult the Departments of Building Research and the British Standards Institution, as well as the Building Departments of the Admiralty, War Office, Air Ministry, Ministry of Aircraft Production, Ministry of Supply, and Ministry of Health. Standardisation had already been carried to a point where it had been possible to issue a Schedule of Wartime Building Supplies, and a further schedule dealing with the standardisation of cooking appliances would shortly be published. Bricks were also being standardised to reduce the number of sizes and steel was being similarly dealt with. It was now necessary to make a survey of materials and component parts so as to reduce to the absolute minimum the number of types available. This would avoid waste of labour and materials and increase the production of essentials. In this connection it was mentioned that the types of doors, windows, camouflage paints and roofing felts would also be greatly reduced. Finally, Mr. Tait said, many people in this country, both laymen and architects, have often feared standardisation in buildings on the grounds that it would lead to lack of individuality and to monotony. It would, however, mainly apply to units of buildings which, by skilful handling of parts to suit requirements, would give all the variety that was required for good work and would be satisfactory both æsthetically and economically.

FORMATION OF AIR TRAINING CORPS.

It was announced last week that H.M. the King had approved the constitution of an Air Training Corps consisting of squadrons, flights and units, which will be recruited at the universities, schools and under local arrangements. Some 70,000 young men will thus be enabled to prepare themselves for service in the Royal Air Force or the Fleet Air Arm. Admission to the new Corps will be open to all boys of 16 years and upwards who are physically fit and who desire eventually to serve in the Royal Air Force or Fleet Air Arm. Boys who are suitable for flying duties will carry out a syllabus similar to that of the Initial Training Wings of the Royal Air Force, while special courses will be available to those who are suitable for mechanical and wireless trades. Responsibility for the training of all units and for the administration and recruitment of local units will be vested in Air Commodore J. A. Chamier, who, as Commandant, will be directly responsible to the Air Ministry. Training will be in the hands of the Director of Pre-Entry Training, to which post Mr. J. F. Wolfenden, headmaster of Uppingham, has been appointed. He will be responsible to the Air Member for Training on the Air Council. It is pointed out that the success of the scheme will depend largely on suitable officers coming forward to command and instruct units. It is therefore gratifying to learn that the response from those with previous Air Force and other service experience, as well as from schoolmasters, has been immediate. The Air Training Corps will be constituted as from February 1, and will take over the existing organisation of local units of the Air Defence Cadet Corps. It is not the intention, however, that it should in any way supersede the organisations already engaged in giving pre-entry training for the other services. It is further interesting to note that arrangements have been made for local education authorities to give instruction, at the Air Ministry expense, in mathematics and English to those who are otherwise suitable for air crew duties. After passing a selection Board these men will be attached to the Royal Air Force, but will continue their civil occupation while they receive instruction. At the same time, they will have an opportunity of undergoing instruction in service subjects with the local Air Training Corps. The Air Training Corps scheme has been developed after consultation with Local Education Authorities, the Headmasters' Conference, the Incorporated Association of Headmasters, and representatives of the voluntary youth organisations. It will not conflict in any way with the activities of the latter. Applications for schools to form Air Training Corps units should be addressed to the Director of Pre-Entry Training, Adastral House, Kingsway, London, W.C.2.

LETTERS TO THE EDITOR.

THE FAILURE OF THE TACOMA NARROWS BRIDGE.

To the Editor of Engineering.

SIR,—The account in ENGINEERING of December 20, 1940, page 481, of the failure of the Tacoma Narrows suspension bridge suggests that this is rather an interesting example of combined structural and aerodynamic instability. Such problems are usually divided by aeronautical engineers into the two classes of flutter and divergence, although, to a certain extent, the distinction is arbitrary. The fact that failure followed a period of more or less violent oscillation certainly suggests flutter in the present case; on the other hand, an approximate numerical investigation indicates the possibility of an approach to a condition of divergence, which may also have been a factor in the ultimate collapse. The linking of the two types of instability, together with the fact that here was an example of flutter of such a low frequency as to be directly observable, combine to impart an exceptional interest to the case from an aeronautical engineering point of view.

The photograph taken shortly before failure clearly shows a one-node vertical flexural vibration of the main span, which may be regarded as confined to the stiffening girder on one side, viz., the compression or windward side. At first sight, this suggests simply an Euler instability of the girder in the vertical plane. It is true that the vertical stiffness in relation to the span is such that the Euler load, even with a node at the centre of the span, is comparatively small, but when the stabilising effect of the tension in the suspension cable is taken into account, it is found that the combination is almost certainly stable at wind speeds of the order quoted. This, of course, also applies to the other possible modes of vertical deflection having more than one node in the span; the mode with no node, i.e., deflection of uniform sign right across the span, is ruled out by the fact that it involves a definite change in the amount of stretch in the cable, the force to produce which is large compared with the other forces under consideration.

The inferred mode of distortion involving vertical movement of one side girder only, the other girder having no serious tendency to deflect since it is itself in tension and is further stabilised by the suspension cable, is in agreement with the observations of large transverse inclinations of the roadway to the horizontal. It evidently results in considerable local aerodynamic lifting forces tending to increase the vertical deflection; and, on investigating the possible numerical values, using the slope of the lift curve for infinite aspect ratio, it is found that the effect is sufficient, at any rate, seriously to reduce the margin of stability and to give an approach to a condition of divergent instability. In this state the natural period of oscillation increases, and a period of 12 seconds, as mentioned in the report, seems quite a possible value.

So far no attempt has been made to account for the building up of the vibration, which has merely been shown to be of a type that might be reasonably expected on aerodynamic as well as on structural grounds. According to the now fairly well-established theory of unsteady lift, the phase of the lift force with fluctuating incidence depends in a prescribed manner on the value of the frequency ratio $\frac{n\,c}{v}$, n being the frequency, c the chord of the aerofoil (in this case the width of the bridge), and v the wind speed. In the present case, it seems doubtful whether the value of this ratio is high enough to give a phase angle corresponding with appreciable negative damping; in all probability the conditions are substantially static, the lift being in phase with the angle of incidence. What may, however, give a virtual negative damping is the effect of stalling, which will probably occur at quite low incidence; the lift will, in consequence, reach its peak value ahead of the angle of inclination, and will not recover to the unstalled value when the inclination starts to decrease, so that there will in effect be a phase difference of the character required to produce negative damping. Further, there will be a sharp increase in drag as the roadway tilts from the horizontal, which, together with the reduced effective depth of girder, will considerably increase the end compressive load in the side girder and add to the instability.

Calculation shows that quite large transverse inclinations, of the order of 45 deg., as mentioned, are possible without inducing such additional loads in the vertical suspension members as would be expected, fatigue considerations apart, to cause failure; but, at such large angles, the side-girder combined bending and compression stresses are becoming serious. Incipient failure of the side girder, however, would further increase the vertical suspension loads, and unsafe values of these latter may then have resulted.

One outstanding feature of the form of oscillation which has been considered is the considerable twisting of the roadway associated with the vertical movement of the compression side from the static level. Numerical investigation confirms that a comparatively small increase in the torsional rigidity of the structure is enough to provide a substantially increased margin of stability, so that this would seem to be the obvious remedy when the bridge comes to be re-designed.

Yours faithfully,

J. LOCKWOOD TAYLOR.

Oakfield, Wellington-road,
Altrincham.
January 6, 1941.

CONCRETE FOR BUILDING.

To the Editor of Engineering.

SIR,—In view of the large amount of used bricks resulting from bomb-damage, it is important to examine the specifications which rule the practice in the use of concrete for building purposes. Many of the established specifications provide for only a limited range of choice among natural stones, and do not offer the alternative of broken brick. Any good type of brick, when broken and properly sized, makes an excellent aggregate for concrete; and, if the details of the specifications are amended, after proper examination of a range of samples made up with brick aggregate, it will furnish an important outlet for much material which is lying at hand, and which, unless used, will cost much money for final disposal.

For any type of brick which is found to yield a crushing strength appreciably lower than that required by a Standard Specification, the increase in thickness required, either for plain walling or many applications of reinforced work, is not likely to approach in cost that of newly-quarried aggregate. The possibilities in the use of brick in place of stone merits the attention of those Institutions responsible for the Standard Specifications, and of the Building Research Laboratory.

Yours faithfully,

A. LINDSAY FORSTER,
M.I.Mech.E., M.I.E.E.

Firhill,
Glasgow, N.W.
January 6, 1941.

WORLD PRODUCTION OF TIN.—According to statistics issued by the International Tin Research and Development Council, the world production of tin during the first ten months of 1940 totalled 193,500 tons, compared with 136,800 tons in the corresponding period of 1939.

THE BETHLEHEM STEEL COMPANY.—The Chairman of the Bethlehem Steel Company, Bethlehem, U.S.A., announced recently that large extension schemes at the Bethlehem, Lackawanna, Maryland and Steelton Works of the company had been decided upon. New plant to be built included six open-hearth furnaces, two batteries of coke ovens and additions to one of the existing by-product recovery plants, and two blast-furnaces. Moreover, two existing blast-furnaces were to be rebuilt and enlarged. The new extensions would add approximately 850,000 tons of steel ingots, 800,000 tons of coke, and 700,000 tons of pig iron to the present annual production of the company. They were additional to the two electric steel furnaces, having an annual capacity of 120,000 tons, and other plant, the construction of which had been authorised earlier in 1940. A portion of the new equipment would be erected within six months and the entire programme would be completed within twelve months.

OBITUARY.

PROFESSOR D. ROBERTSON.

WE regret to record the death of Professor David Robertson, which occurred at Bristol on Wednesday, January 8, at the age of sixty-five. He was well known as an educationist and had made many contributions to the literature of electrical engineering.

David Robertson was born at Helensburgh on December 26, 1875, and was educated at the Hermitage School in that town. He received his technical training at the Glasgow Technical College, under Professor Andrew Jamieson, and at Glasgow University. At both of these institutions he obtained high honours, receiving the Pender Gold Medal at the former and being Walker prizeman at the latter. After a period of training in the works of Messrs. James White, Limited, Glasgow, he was appointed lecturer in electrical engineering at the Bradford Technical College, but after a two-years' tenure of this post he became professor of electrical engineering at the Merchant Venturers Technical College, Bristol. In 1909 this was converted into the Department of Electrical Engineering in Bristol University and Robertson was appointed the first professor, a position he was still holding at the time of his death.

For many years Robertson had suffered from a physical disability which confined him to an invalid chair and prevented him, in his own words, from being "of much service outside my own laboratory." Nevertheless, he was an indefatigable worker, as will be gathered from the long list of publications for which he was responsible. Perhaps the most important of these were his books on the *Mathematical Design of Transformers*, and *A Treatise on Transformers*, the latter being written in collaboration with Professor H. Bohle. Other publications include *A Method of Studying Armature Windings by Means of Winding Diagrams*, *Electrical Meters on Variable Loads*, *An Electrical Timing Device for Short Intervals*, *Experiments with the Slide Wire Bridge*, and a number of papers on the whirling of shafts, a subject to which he devoted much attention during the latter part of his life. He also designed the mechanism for the great clock of the University of Bristol.

Robertson was elected an associate of the Institution of Electrical Engineers in 1900, was transferred to the class of associate member in 1908, and became a member in 1912. He served as chairman of the Western Centre in 1916-17. He was also a member of the Institution of Engineers and Shipbuilders in Scotland.

MR. T. W. K. CLARKE.

THE death of Mr. Thomas Wigston Kinglake Clarke, which occurred at Weobley, Herefordshire, on January 3, removes one of the early pioneers of aviation, who had the great misfortune to suffer from total blindness during the last few years of his life. He was the son of Mr. James S. Clarke, and was born at Marshfield, Gloucestershire, on April 17, 1873. After attending Bath College, he went up to Caius College, Cambridge, and secured the B.A. degree with first-class honours in the Mathematical Tripos and first-class honours in the Engineering Tripos. He was Senior Scholar of Caius College and was awarded the Schuldham Prize. After leaving Cambridge, he became senior mathematics master at Bedford County School in 1896 and started the engineering department there. He relinquished this appointment in the following year, however, to join the staff of Messrs. Perry and Company, contractors for the construction of the Bakerloo Tube Railway, as assistant engineer. Three years later he proceeded to South Africa, on active service, as a trooper in the Imperial Yeomanry, and in the course of the campaign received a severe wound which confined him to hospital for some months. On returning home in 1901, he became lecturer in mathematics and engineering at Rugby, and, later, at Seafield Engineering College, Nottingham University. In 1903, Mr. Clarke once again took up civil-engineering work, becoming assistant resident engineer, under Sir James Szlumper, on the construction of the Piccadilly Tube Railway. He

continued in this capacity for three years, but, in 1906, broke entirely new ground by founding the firm of Messrs. T. W. K. Clarke and Company, aeronautical engineers, Kingston-on-Thames. The works, which was claimed by him to be the first of its kind in this country, was employed on the manufacture of glider and aeroplane parts, scale models, propellers, and flying models known as "Clarke's Flyers."

In 1913, however, Mr. Clarke terminated his career as a manufacturer, to become a technician at the Royal Aircraft Establishment, and, when the Air Ministry was formed, he was appointed Scientific Officer, Grade I, continuing in this capacity until his retirement in 1938. He was responsible for mathematical calculations and physical experiments relating to problems of balance and stability, and also carried out numerous mechanical tests on metal plates, struts, and other aircraft parts. In the second year of the war of 1914-18, he was "lent" to Mr. Mackenzy Kennedy and served until 1919 as chief engineer on the construction of large Sikorsky aeroplanes. Mr. Clarke, who was for some years an associate member of the Institution of Civil Engineers, became a Fellow of the Royal Aeronautical Society in 1907, and, in 1932, received the Bronze Medal of the Society for his paper "Some Advance in Aeronautical Design." He served on the Council of the Aeronautical Society from 1911 until 1913.

TEMPERATURE MEASUREMENT IN MOVING MACHINERY.

THE methods of measuring temperature in parts of machinery when those parts are in motion had not, so far as we are aware, received attention as a separate subject until Professor H. Wright Baker, D.Sc., in November, 1940, presented a paper entitled "The Measurement of Temperature in Machinery in Motion," before the Manchester Association of Engineers.

The paper opens with the statement that, though some of the methods referred to may seem rather crude, it should be remembered that in a number of instances those requiring a special and high-refined technique are not really needed for practical purposes. Thus, in the internal-combustion engine, in which the temperature fluctuations of the working fluid are very great, the fluctuations in the surface of the metal will be found to be of a much lower order than might be expected and to be quite negligible a few hundredths of an inch below the exposed surface. A simple measurement of the mean metal temperature taken conveniently close to the face, in such circumstances, will usually supply the information required with all the accuracy necessary. A knowledge of limits between which a temperature may lie may be of greater value than a guess at the correct temperature.

The paper is divided into three sections, dealing with optical, electrical and irreversible-change methods of measuring temperature, the mercury thermometer being stated to be usually inapplicable for the measurements concerned on account of its fragility and the difficulty of reading it. It is stated, however, that maximum thermometers were used by Dr. F. D. Smith for the measurement of piston temperatures. These were inserted in holes drilled parallel to the gudgeon pin and measured $\frac{3}{4}$ in. long by $\frac{1}{4}$ in. in diameter. Doubts were expressed concerning the effects of vibration even when thus placed. Optical pyrometers are limited in use to temperatures in excess of 600 deg. C., at which solid bodies first become visible in the dark. Of the types of instrument available, the absorption spectroscopes are dependent upon measurements of the amount of light-absorbing material which must be placed before the observer's eye to neutralise completely the visibility of the rays proceeding from the body the temperature of which is being measured. In the "wedge" and "Pyromike" instruments the absorption is effected by red glass in the form of superimposed wedges and by a coloured liquid contained in a glass-ended telescopic capsule, the measurement of the total glass thickness employed and the effective length of the capsule providing, after calibration, a measure of the temperature. It is stated that both these instruments suffer from the inability of the eye to form a rapid judgment of complete neutralisation, since the time required for ocular sensitiveness to be reached may be inconveniently long.

The comparator optical instruments may be represented by the "Shore" and "disappearing filament" types. In the Shore pyroscope a small mirror, placed obliquely in the axis of a telescope through which the body is viewed, is illuminated by a small standard flame the amount of light from which is varied by means of an iris diaphragm of transparent red material in front of it. The iris aperture is regulated by a control disc which is turned until the images of the mirror and the object viewed appear to merge completely, the temperature being then read from the periphery of the disc opposite a small fixed pointer. In the disappearing-filament instrument the illuminated mirror is replaced by the tip of the filament of a small electric lamp, a resistance in the circuit of which provides the necessary variations of intensity of glow. Dr. Baker states that this instrument, since it is unaffected by draughts and has a better form of comparator, will be found more convenient, though a good deal can be done with the Shore instrument by improvising a screen, such as a large, open-topped biscuit tin, in which the instrument is shielded.

These instruments have been used with success for measuring the temperatures of exhaust valves in internal-combustion engines, the valves being viewed just below the head, and at a distance of about 4 ft., through a port in the exhaust pipe. This involves the operator working in a stream of exhaust gases but, owing to the speed at which the instrument can be used, the inconvenience is not serious unless extremely rich mixtures, which complete their combustion with violence after leaving the port, are used. Smoke and oil in the exhaust gases seldom screen the valve from observation to any great extent. This method of measurement has been checked by a thermocouple inside the valve, but the thermocouple was found to have a life only sufficient to obtain the desired confirmation. For certain purposes the "total radiation" pyrometer may be considered. In this instrument the radiations from the heated body is focused upon a minute blackened thermo-junction which develops a rise in temperature corresponding to the intensity of the rays. The temperature of the couple is recorded electrically and from it that of the body may be deduced. For work at all but slow rates of temperature variation the time-lag of the instrument may be a serious objection, but this has been overcome recently by the substitution of a photo-electric cell for the thermocouple, the instantaneous voltage generated by the cell when the rays fall upon it giving a measure of the temperature sought. Professor Baker seems to view this development with some misgiving, since he thinks that valve-amplification may introduce the possibility of serious errors unless a regular system of checking is adopted.

That part of the paper dealing with the use of the thermo-couple is perhaps the most detailed and describes a number of arrangements which have been adopted by various investigators in order to convey the thermocouple indications from such a moving part as a piston to the stationary instruments outside the engine. These consist, for the most part, of swinging levers, but the earliest methods are also described. Thus, in one instance, the wires from the piston crown were led through a tube screwed into it and passing through a gland in the cylinder head, outside which a link motion carried the wires to the instruments. Trouble was experienced owing to seizure in the gland but a later investigator at Cambridge has used the method with success, though the presence of the tube must be expected to interfere with the combustion process. Another method was that of attaching the tube to the under side of the piston and leading it through the crank chamber, the reciprocation of the piston being taken up by the flexibility of the leads to the instruments. Yet another arrangement was to bring the wires together into a cable which hung below the piston and was guided to prevent excessive flicking. Satisfactory results were claimed, and were largely, no doubt, due to excellent insulation, though the guiding would appear to have been inadequate, at any rate at high speeds.

It will be realised that as the operative junction of the thermocouple is normally secured to the part in motion, portions of the circuit are subject to constant vibration and special precautions may have to be taken to prevent deterioration or fracture of the wires or their insulation. In many cases the circuit may be broken and lengths of wire of other metals than those forming the couple may be inserted, provided that the supplementary junctions of each pair thus formed are kept at the same temperature, or that the metals of which the inserts are formed are suitably chosen. For the operative junction, platinum and an alloy of platinum and rhodium are used for the highest temperatures or where great accuracy and permanence of calibration are required. These metals are, however, very expensive and, as the voltage generated is low, about, 4·4 millivolts for a temperature difference of 500 deg. C., specially sensitive instruments must be used for its measurement. Combinations of Eureka with copper (the voltage generated being 27 millivolts for 500 deg. C. temperature difference), iron or silver, all have considerable temperature ranges and also nickel and Nichrom. Some of these metals are specially liable to deterioration when subjected to moisture, oxidation or vibration, but two of the most sensitive in these respects, viz., copper and iron, have the great advantage that flexible sections of the circuit may, at times, be made by inserts of copper flex or of spring-steel or "Bowden" wire, without the risk of producing appreciable parasitic currents even when the subsidiary junctions so formed cannot be adequately controlled with regard to temperature. Brushes and slip-rings may also be included in the circuit, provided that proper care is taken in their design to prevent variations in resistance.

For most purposes a direct-reading millivoltmeter may be used for measuring the potential produced, but for the highest accuracy, or in all cases where the completion of the circuit is intermittent, or is liable to variations of resistance, a potentiometer method must be employed, the thermocouple wires then forming one side of a Wheatstone bridge circuit on which the potential is balanced against a variable but known E.M.F. The galvanometer is then required only to indicate the presence or absence of small potential differences without showing their magnitude and so can be made extremely sensitive. All the switches used for currents of very low E.M.F., and all junctions in the circuit must be entirely reliable, a condition which is not always easy to obtain in the presence of oil spray or vapour.

When temperature tests are being made, especially with small engines, the presence of links and levers in the mouth of the piston may seriously affect the air flow, which has a considerable effect in cooling the piston. A method used in testing light high-speed engines, involves the employment of portable "contact" thermocouples, which instruments have long been used for measuring the surface temperature of steam-heated and other rolls. In these tests the engine is first warmed up under given running conditions and, after cutting out the ignition, is then suddenly brought to rest by means of a powerful brake applied to the flywheel. A preheated thermocouple junction mounted on a handle is at once inserted in the cylinder, often through the sparking-plug hole, and pressed against the piston crown. The junction rapidly assumes the temperature of the piston and registers its cooling in the cylinder, the extrapolation of the time-temperature curve, preferably plotted logarithmically, to the instant when the engine was stopped, giving the working temperature of the piston. With a suitably-designed test bed it is possible to obtain a first reading of piston temperature in between 3 seconds and 5 seconds from full load running, independently of the engine speed, and readings can generally be repeated to within $\pm$ 2 deg. C.

The use of the cathode-ray tube as a highly-sensitive galvanometer in a bridge circuit has made possible an alternative method of temperature measurement. Thermocouple leads from the piston crown are brought to a number of insulated projecting pins on the bottom edge of the piston skirt. At the bottom of the piston stroke these pins make contact with similar spring-loaded pins coupled to the instrument leads. Provided that the pins are in contact for an adequate time, the bridge can be satisfactorily adjusted. This method, which allows virtually continuous recording over long periods, seems to have many advantages over those methods employing links or that which involves the extension of the cooling curve, and is applicable to all engine speeds and sizes. An ingenious application of the thermocouple to the determination of the temperatures of cutting tools was made by Mr. E. G. Herbert, who used the E.M.F. generated by the junction of the metals forming the tool and work. A number of combinations of metals were used successfully, though some of these showed a reversal of polarity at certain temperatures and the interpretation of the records thus required a little extra care.

On the question of irreversible-change methods, Professor Baker is a little less detailed in description. One method, based on the use of fusible plugs in boilers, is the insertion of small plugs of various alloys melting at known temperatures in holes drilled in the piston, and secured by light peening. After running, certain of these plugs will have melted or lost the sharpness of their outline and these facts are noted. The holes may then be cleared or new ones drilled, and a modified group of plugs inserted and tested. Experience soon enables suitable ranges of plugs to be selected and the temperatures may be mapped with reasonable accuracy. A less positive method seems to be that of inserting pieces of felt behind the piston rings, the temperatures of which are judged by the presence or absence of the deterioration produced by heat. At particular temperatures certain light-alloy piston materials undergo internal structural alterations which can be revealed by etching, but the critical temperature is both unique and high and the test involves the destruction of the piston. An improvement on this method depends upon the irreversible colour changes affected at specific temperatures by certain thermo-paints. The piston or other part is painted in determined patterns with a range of paints exhibiting their colour changes at different temperatures, the boundaries of the coloured areas showing, after heating, the change point isotherms.

14-TON WELDED RAILWAY WAGON.

THE welded railway wagon, having a carrying capacity of 14 tons, shown in Figs. 1 to 3, on this page, is of interest since it departs considerably from conventional design. What is gained by this departure will be apparent from the fact that the comparable standard Railway Clearing House wagon has a capacity of 12 tons and weighs 7 tons, while the new wagon, though carrying 2 tons more, has a weight of 6 tons 15 cwt., and this increase in capacity and decrease in weight does not result in any loss of strength. The saving of dead-weight should be reflected in railway working by the increase of pay-load to dead-weight, the new wagon having a ratio of 2·07 as against 1·71 for the standard Railway Clearing House wagon. As regards strength, it is stated that the new wagon has proved very satisfactory in severe shunting trials, in which a number of other wagons were damaged although the welded wagon was not even distorted.

The wagon has been designed, and is manufactured, by Messrs. The Butterley Company, Limited, Ripley, near Derby, and as will be seen from the general view, Fig. 1, has corrugated hinged ends. The side door is stiffened by a continuous rectangular corrugation round its edge. In the construction of the underframe, the more usual assembly of bottom plates lying on a frame of channels has been discarded for an integral construction in which the bottom plate is bent over to form the frame. This construction will be clear from the view of one section given in Fig. 2, this view showing the underside of the section. There are three sections in the complete bottom, as shown in Fig. 3. Each section is made of a single steel sheet bent into channel form at the edges, the centre section being, in addition, arranged to leave the openings for the bottom doors. The three sections are welded together, a web-plate being inserted between them to form the cross-bearers. Other members forming the diagonals and buffer trimmers are then welded in place, as shown in Fig. 2. Quasi-Arc electrodes and equipment were used throughout. The running, buffing and draw-gear arrangements are all to Railway Clearing House standards.

The body is attached to this combined bottom and underframe, which is both stiff and strong. The body is of the Butterley patented design, having a rolled-steel top belt bolted together. The firm's bolted construction, it is stated, saves as much as 50 per cent. on wagon repair charges by the ease with which it can be dismantled in sections. As the body construction is not new but has been proved in long service, its combination with the new integral bottom and underframe should make the new wagon exceptionally cheap to maintain.

NOTES ON NEW BOOKS.

Dry Batteries: How to Make Them. By G. BERNARD HUGHES. London: Hutchinsons Scientific and Technical Publications. [Price 6*s.* net.]

THE dry battery is the Cinderella of the electrical industry and but little information regarding its construction and employment is available except for the exiguous accounts which appear in the pages of elementary text-books. The applications of this source of current are very wide, and since the war, in particular, the black-out and other events have added greatly to the normal output of millions of cells each year. Mr. Hughes' book should, therefore, be very welcome, as it contains a great deal of useful data on the evolution and construction of torch and flash-lamp batteries, general purpose cells, inert cells, and high-tension wireless batteries, accompanied by full details of the materials and processes used. Unfortunately, he is not content to leave it at that, but suggests, as we understand it, that a successful manufacturing business can be built up on the foundation which he provides. Scientific education and technical training, he says, are unnecessary, and the outlay on plant need not be large. This conclusion we very much doubt, and even were manufacture possible on the amateur lines suggested, market conditions would prevent the more difficult but still essential selling side from being successfully developed, especially at the present time. On the other hand, the technical data are good, and the illustrations clear.

Diesel Engines and Diesel-Electric Power. By E. L. RICHARDS. London: Sir Isaac Pitman and Sons, Limited. [Price 10*s.* 6*d.* net.]

WITH the increase in the number of oil engines in use, a greater number of operators, drivers and maintenance men are required to have practical knowledge of their construction and use. Books dealing with problems of design are not, in general, the most suitable for these men, whose desire is usually for publications which are simply written, well illustrated, conveniently sectionalised to allow of easy reference to details of engines and equipment, and contain as little mathematics as possible. The present book is of this type and deals with various important uses of oil engines, including electricity generation. The term "Diesel engine" is applied to all the various types of heavy-oil engines mentioned. The treatment is on conventional lines, beginning with descriptions of the types of engines and their cycles, and their constructional features, and continuing with chapters on the main items of equipment, such as fuel pumps, governors, injection and combustion, fuels and starting systems. Further chapters describe more fully the constructional features, operating procedure and maintenance; while the final chapters deal with Diesel-electric plants and their operation. Most of the sections follow the same plan, first describing the functions of the equipment discussed and then detailing methods of operation, setting out possible troubles and their probable causes, and concluding with questions on the subject of the chapter. The text is adequately illustrated by diagrams and half-tone reproductions. The descriptive matter relates to American plant, but most of it is of general application. The book is well arranged and can be recommended to those for whom it is intended.

14-TON WELDED RAILWAY WAGON.

MESSRS. THE BUTTERLEY COMPANY, LIMITED, DERBY.

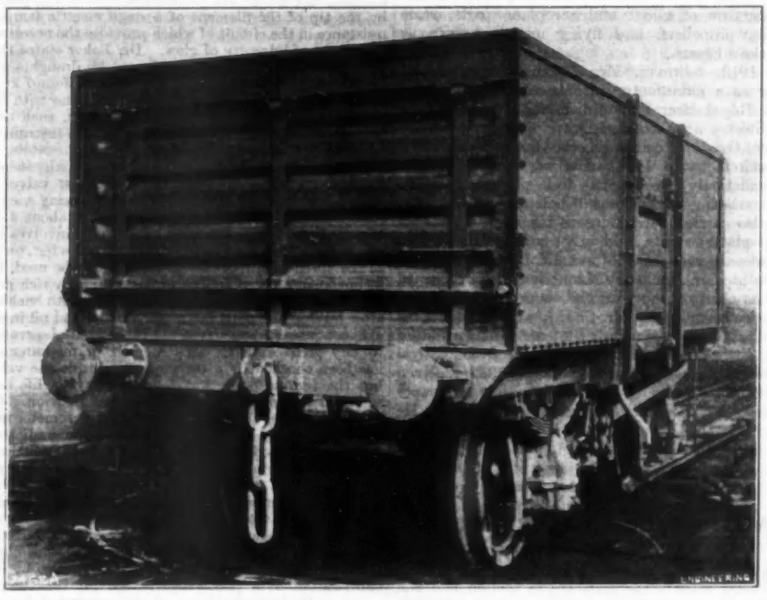


FIG. 1.

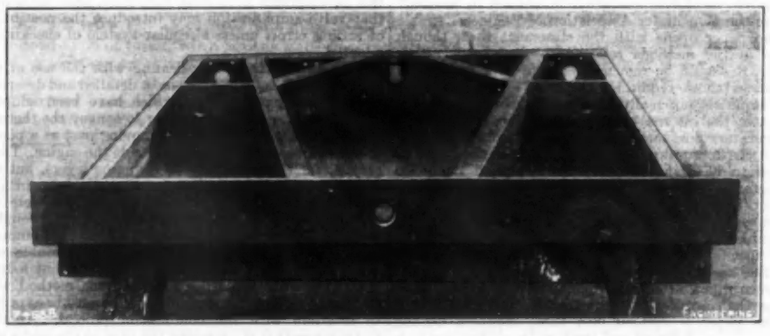


FIG. 2.

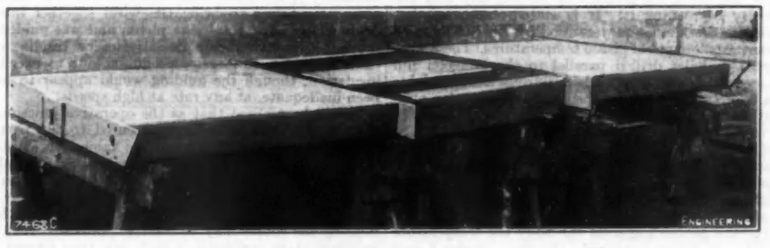


FIG. 3.

LABOUR NOTES.

THE Ministry of Labour and National Service states that the number of men and boys registered at Employment Exchanges in Great Britain as wholly unemployed, at December 9, was 265,011—a decrease of 43,120 compared with November 11. Those registered as on short time or otherwise temporarily suspended from work, on the understanding that they were shortly to return to their former employment, numbered 84,850—a decrease of 11,727 compared with November 11. Those registered as unemployed casual workers (being persons who normally seek their livelihood by jobs of short duration) numbered 20,435—a decrease of 3,113 compared with November 11.

The corresponding figures for women and girls at December 9 were 276,889 wholly unemployed, 56,998 temporarily stopped, and 1,096 unemployed casual workers. Compared with November 11, the numbers wholly unemployed showed a decrease of 18,221, those temporarily stopped a decrease of 9,789, and unemployed casual workers an increase of 69. At December 16, there were 35,508 women registered as applicants for work in districts to which they had been evacuated—a decrease of 3,686 compared with November 18.

It is announced that the Minister of Labour and National Service has formed a new branch of the Ministry, to be known as the Engineering Branch, to advise on engineering matters, especially in relation to the work of the Munitions Labour Supply Organisation. Mr. G. Stevenson Taylor is to take charge of the new branch.

The claims of the Amalgamated Engineering Union and the National Union of Foundry Workers for increases of wages were heard by the National Arbitration Tribunal on Tuesday last week. Both organisations desire an increase of 3*d.* an hour and restoration of certain working conditions in force in June, 1931. The case for the unions was presented by Mr. Tanner, president of the Amalgamated Engineering Union, and Sir Alexander Ramsay, Director of the Engineering and Allied Employers' National Federation, replied for the employers. On the following day, the Tribunal heard the joint claim of the other engineering unions, which is for an increase of 10*s.* a week and the equivalent on piece work rates. The Tribunal's findings will be issued when the joint trades' application to the Shipbuilding Employers' Federation has been heard. This claim is also for an increase of 10*s.* a week and the equivalent on piece-work rates.

The National Arbitration Tribunal has issued its award on a claim by the Engineer Surveyors' Association against the British, National and Vulcan Boiler Insurance Companies. On behalf of its members, the Association asked for a salary scale commencing at 300*l.* a year, rising by annual increments of 20*l.* to 500*l.* a year. The award gives 275*l.* for the first year of service, 15*l.* a year advance for the following two years, 10*l.* a year advance for from the fourth to the ninth year, and then 15*l.* a year advance until, after 12 years' service, the rate is 425*l.*

The task of placing friendly aliens in industry is, as is known, in the hands of the International Labour Branch of the Ministry of Labour and National Service, which keeps in close touch with the Allied Governments, the foreign trade unions in this country, and the refugee organisations, and has the support of the Trades Union Congress General Council and the British Employers' Confederation. During the last six months, it is stated, the average number of employment permits issued by Employment Exchanges to unemployed foreigners has been 3,000 a month. A condition of these placings is that foreigners shall have the same wages and conditions as British subjects, and it is also the policy to encourage the placing of working men and women as far as possible by national groups: for example, Belgian, French, Norwegian, and Spanish groups are employed in debris clearing and repair work in London; Belgians, Danes, and Norwegians in forestry; Norwegians in rope works; Belgians, Czechs, French, Poles, and others in engineering and aircraft works; Belgians, Dutch, and Poles in diamond cutting and polishing; and Belgians, Dutch, and other fishermen in naval auxiliary work.

One way of access to employment will be through the Government training centres which, it has been arranged, shall give training to foreigners, both men and women. Unemployed foreign women in the London area are thought to number about 5,000—far more than the number of women on the register—and a special effort is to be made to recruit them for training and industrial work. To assist the placing of foreigners central employment exchanges are to be established in London. Two difficulties stand in the way of employing foreigners. One is the absence of accurate knowledge of their qualifications, which would be removed by a scheme of registration, and the other is a certain amount of prejudice in the workshops. To overcome this prejudice, the international workers are to be distinguished by a badge which, it is hoped, will serve as a credential and a passport. For unemployment and health insurance the foreigners will qualify in the normal way and will have equal rights with British workmen.

Writing in the December issue of the International Association of Machinists' *Journal*, General Vice-President George C. Castleman says that in the recent presidential election, the American public "called on their great leader of the past seven and a half years to give four more years of his life championing the cause and principles on which our forefathers founded this, the greatest of all democratic nations—free speech, a free Press, the right to worship whom and how we please, and freedom to follow our pursuit of happiness as we see fit." "The man of their choice to fill the high post of Chief Executive of this nation," he continues, "President Roosevelt, has liberalised the interpretation of the precious 'Bill of Rights' to give the great masses of common, honest working people their inherent 'Rights' under this, the greatest of all humanitarian documents. Under the administration of President Roosevelt, organised labour and the common people of the United States have advanced farther towards their rightful station in the life of this nation than under all the other Presidents in the history of the United States of America." The International Association of Machinists is the equivalent, in the United States and Canada, of the Amalgamated Engineering Union. It is affiliated to the American Federation of Labour.

Mr. Arthur Deakin, the acting general secretary of the Transport and General Workers Union, says, in the course of a contribution to the organisation's official publication, the *Record*, that "it is apparently due to the failure effectively to organise production that the agitation continues for the mobilisation of labour by industrial conscription." "Right from the commencement of the war," he continues, "at frequently recurring intervals, this demand has been made. Rigidly disciplined labour readily appeals to a certain type of mind and is associated with an utterly false impression that it provides a ready supply of cheap labour. This, of course, is fallacious. The cost of equipping, training and maintaining by family allowances the dependants of men serving in Military Labour Corps, not forgetting the fact that the primary need for such units is a necessary part of the development and maintenance of our fighting forces, would be even greater than the cost of the employment of civilian labour. The mere transference of labour from one status to another would not contribute one iota to the effectiveness of our industrial organisation. The only possible effect of such duplication would be to make for still greater confusion, at the same time destroying the morale of the nation. Given a square deal, Labour will discipline itself and will continue to make great sacrifice until victory is assured."

According to official data, the number of persons in employment in Germany at the beginning of the war was 24,460,000, of whom 16,330,000 were men and 8,130,000 women. These totals, compared with the figures for June, 1939, showed a marked decrease for men and a slight increase for women. If, however, men called to the colours are left out of the reckoning, the figures show that the male labour employed has increased during the period under review by about a million, consisting of boys leaving school, elderly workers who have resumed to serve the war's demands for labour, persons who have not hitherto carried on any paid occupation, aliens and the populations of the new territories in the east. The number of unemployed persons which reached its maximum of 257,000 at the end of January, 1940, had fallen by the end of June to 39,000 (of whom only 3,500 were employable), or 23,000 fewer than at the beginning of the war. The number of workers on short time, in receipt of assistance, was 8,350.

The number of women employed, which up to the end of February, 1940, was declining, owing to certain causes such as the increase in the marriage rate, returns to undertakings carried on by relatives, adequacy of family incomes, etc., has again increased. It exceeds the pre-war figure by 200,000, and that at the date of the beginning of the four-year plan by 1,600,000 (old Reich only). Over half a million alien workers and from 600,000 to 700,000 prisoners of war have been placed at the disposal of agriculture, while 400,000 aliens and 200,000 prisoners of war are employed in industry. There have, of course, been considerable additions to these figures since the official data were published.

MECHANICAL GEARING FOR LARGE POWER TRANSMISSION.*

By L. M. DOUGLAS.

GEARS may be divided into two functional classes (without stipulating any clear line of demarcation between them), termed, for convenience, "high-speed" and "low-speed" gears. In the former type, the peripheral, and consequently the rolling, speed of the tooth profiles is sufficiently high to maintain a film of lubricating oil between the inter-engaging teeth, which, therefore, do not come into physical contact. In the latter type, the peripheral speed is insufficient to maintain such an oil film, the teeth come into actual contact, and the only lubrication is of the "greasy friction" type. In function, these two types are analogous to high-speed and low-speed journal bearings. Obviously, the load-carrying capacity of high-speed gears is many times that of the low-speed type and its frictional resistance is negligible in comparison. However, there seems to be little doubt that the high-speed type of gear came into being in quite an incidental way and not because its possibilities were realised beforehand. It was the introduction of the high rotary speed engine, particularly the turbine, that brought it into existence. (It must be borne in mind that, at the time that gears were first employed at high speeds, the principles of film lubrication were little known to the ordinary practical engineer.) Apart from speed, the high-speed gear does not differ in any material way from the low-speed gear, and the development of the fundamental theory of gearing had been accomplished long before gears were used at such speeds as to bring them into the high-speed zone. Recently, a new development has taken place, principally in connection with aeroplane-engine drives, in which the gear teeth are made with extreme accuracy, of very hard material, and are generally used with an "extreme-pressure" lubricant. These gears are used with very high loading rates, evidently quite satisfactory for a short life, but so far they do not appear to have been employed for very large powers.

In view of the fact that gearing is to-day so much associated with ship propulsion, it is interesting to note that it was first used in this connection many years ago to perform an exactly opposite function to that which it is called upon to perform to-day. It was employed as a speed-increasing means, to harmonise the very slow-speed engines of those days with paddles or propellers, which required a higher rate of revolution. The early engine was much too slow for the propeller or paddle; in the next phase, the then high-speed engine was developed with a rotational speed equal to that of the propeller or paddle, so that gearing was unnecessary; in the last phase the engine (turbine) has so great a rotational speed that it requires a reduction of anything up to 65 times to harmonise it with the propeller speed.

Powers developed by slow-speed gears were necessarily relatively small, and the real development is wholly associated with high-speed gears of the helical type. Probably the earliest actual gears of this type were those which De Laval used, about 1890, to gear down his very high-speed turbine. The loads on these gears, which were double-helical, appear to have been quite moderate. From a published description of a 500-h.p. installation, the following approximate particulars of these gears have been obtained:—Pitch-circle diameters, 2·76 in. and 18·4 in.; revolutions per minute, 9,870 and 150; tooth speed, 120·6 ft. per sec.; face width, 23·6 in.; load, 96·5 lb. per in. face = 35 D (D being the diameter of the pinion in inches). In 1897, Sir Charles Parsons fitted a small twin-screw launch with a geared-turbine drive, a single 10-h.p. turbine and pinion driving two gear wheels, one on each propeller shaft. The gear was single-helical, pitch-circle diameters, 0·829 in. and 11·68 in.; r.p.m., 19,720 and 1,400; tooth speed, 71 ft. per sec.; face, 1·5 in.; load, 26 lb. per in. = 31 D. About this time, he also used double-helical gearing for driving small dynamos at about 2 to 1 reduction ratio. One of these was 300 h.p. at 9,600 r.p.m. to 4,800 r.p.m. He estimated the efficiency of transmission at about 98 per cent. by the heat loss, but complained that the gear was noisy. In 1906, Parsons described, in his British Patent 13019/06, a ship-propulsion system comprising a direct-driving reciprocating engine and an exhaust turbine or turbines geared to the same propeller shaft. Four types of gear are described, namely, of electrical, worm, chain, and helical. The last were the high-speed type, but these proposals were not put into actual practice until several years later.

A double-helical, double-reduction gear for driving a rolling mill at Calderbank Steel Works was installed in 1910 to transmit 750 h.p. from 2,000 r.p.m. to 70 r.p.m. It actually transmitted 556 h.p. at 67 r.p.m. The

* Paper read before the North-East Coast Institution of Engineers and Shipbuilders, Newcastle-upon-Tyne, on Friday, November 29, 1940. Abridged.

first-reduction pinion diameter was 7·1 in.; tooth speed, 60 ft. per sec.; load, 212 lb. per in. = 30 D. The second-reduction pinion diameter was 14·9 in.; tooth speed, 24 ft. per sec.; load, 795 lb. per in. = $206\sqrt{D}$. It is probable that there were other cases of the use of high-speed gearing during this period in connection with land installations where high-speed machines, particularly electrical machines, were also coming into being.

Undoubtedly, the most important application of high-speed gears was what has been described as "the classical experiment" of fitting geared turbines to s.s. Vespasian in 1909-10. These gears were double-helical and transmitted 1,095 h.p. from 1,450 r.p.m. to 53 r.p.m., and had a load of 390 lb. per in. face on a 5-in. pinion = 78 D. The subsequent extensive use of geared turbines for ship propulsion for all but small-power vessels, and their exclusive use for all large-power vessels, is well known. Fig. 1 shows the total output, in shaft horse-power, of marine geared turbines up to 1938. During this period, gears were put into service transmitting over 60,000 shaft horse-power to a single propeller shaft, and nearly 30,000 shaft horse-power through one pinion.

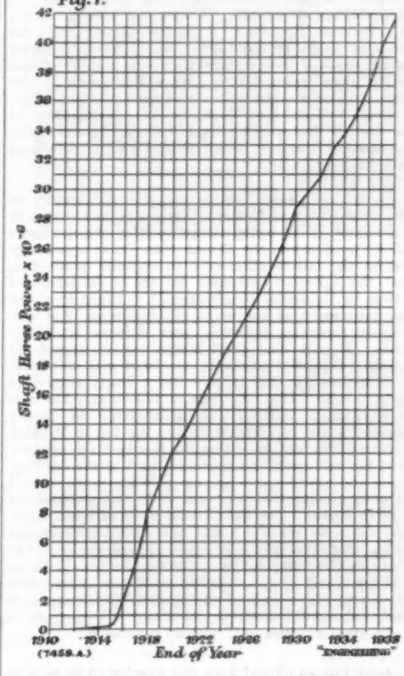
In the early years of this period of development (1910-1940), the mechanical gear was attacked in two different ways. The first was the frontal attack of competitive systems of transmission, namely, the hydraulic and electric drives. The mechanical gear survived this attack, and by virtue of its simplicity, lightness, small size, high efficiency and reliability, it still remains the most attractive type and occupies much the most prominent place in the sphere of large power transmission. The other attack was much more subtle, and consisted in ascribing all kinds of defects to the simple double-helical gear and prescribing complicated mechanisms to meet the supposed difficulties. Most of these were directed at obtaining a better distribution of the load across the width of the gears. Some of these devices were:—Floating frame for the pinion bearings; spring-supported bearings; multiple helical gears with load-equalising means; driving the pinion from the middle or from each end or from the middle of each helix (to reduce torsional deflection); the nodal drive; quill-shaft drives; parallel drives (one pinion driving two or more wheels); differential gears; various methods of making the teeth more flexible, including laminated gears; allowance in cutting or assembly for the deflection under load; and many more. There was, for some years, a regular spate of patents and proposals of this type. Few of them were actually used and practically all of them passed into oblivion. (The pinion journals take up such a position in their bearings that they can readily adjust themselves in the direction of the load to accommodate minute discrepancies of alignment, etc.) The quill-shaft drive is probably the only one used at all to-day. The mechanical gear thus survived this concentrated assault and is used to-day in practically the same simple form as was employed in the Vespasian. It can be said that this phase of the technical development of gearing was largely negative and consisted in resisting unnecessary refinements and complications. A most important landmark in the early years of this period was the introduction by Parsons, about 1912, of the creep mechanism for gear-cutting machines, to enable them to produce gears capable of silent operation.

About 1919, the first case occurred of torsional oscillation of the propeller shaft of a geared-turbine installation at about the full-power revolutions. The machinery of the vessel in question was placed well aft, with the result that the short propeller shaft had a much higher natural frequency of torsional oscillation than is usual with the machinery amidships, and this frequency was near to synchronism with the frequency of the impulses set up by the individual propeller blades passing the stern post at full-power revolutions. The consequent augmentation of the load on the gears was quite serious and had a noticeable effect on the gears at definite angular positions round the main gear wheel. This difficulty was got over, in this installation and in subsequent designs, by altering either the frequency of the impulses or the natural frequency of the shaft, so that synchronism either was never reached, or occurred at quite a low power. These seem to be very obvious remedies, now that the phenomenon is so well understood, but the cause and cure were certainly not so obvious at that time. About 1921, a halt was threatened as a result of several cases of pinion-tooth breakages. The percentage of gears affected was small, but, occurring all about the same time, they had a disturbing effect. However, the difficulty was soon overcome.

For a few years prior to 1922, much attention was given to the problem of mitigating the effects of the angular-pitch errors, inherent in all gears at that time. The errors of the two helices of a gear were usually out of angular phase with each other, and in order to maintain contact on both helices the pinion moved rapidly to and fro axially. This was usually termed "shuttle action." The first attempt at reducing this effect was to dispose the wheel angularly on the gear-cutting machine during the cutting operations of the two helices, so that their angular-pitch errors were in phase. It had quite a beneficial effect in most cases. Another attack on this problem was to incorporate an elastic damping device in the primary wheels of a double-reduction gear. This was only done in one installation, and little is known of its effectiveness beyond the fact that the gear has functioned quite satisfactorily for 17 years. The complete solution of this problem was the practical elimination of angular-pitch errors of the gears and was commenced in 1922. During the whole of this period, there was going on, unobtrusively, a methodical attack on all the problems which had to be solved if gearing was to be used with maximum effectiveness, that is, with high efficiency and load-carrying capacity and with freedom from breakdown. The principal requirements for fully satisfactory operation are:—(*a*) Sound design, construction and proper assembly; (*b*) satisfactory material; (*c*) accuracy; (*d*) effective lubrication; and (*e*) balanced parts. The following is a brief review of the development and present position in regard to these items.

Design and construction have changed remarkably little, and not at all fundamentally. Type of tooth is

Fig. 1.



probably the most important feature of design, and in this respect no change at all is to be noted, practically all gears of the class under discussion being involute or cycloidal. They are both absolutely sound in principle of manufacture, operation, etc., the only difference being that there are certain practical advantages peculiar to the use of the involute tooth, which is the sole reason why the majority of gears are of this type. The most important is that involute gears will gear correctly and give uniform transmission at any centre distance at which they are in mesh. In actual practice, the running and cutting centre distance may not be exactly similar, or the centre distance may be varied by eccentric mounting, causing the gear to swing or wobble in and out of mesh. It is true that the cutting centre distance can and should be made to correspond exactly to the running centre distance and the alignment should be free from any defect, but there is one cause of lack of correspondence which is not under direct control, and that is the change of running centre distance due to differential thermal expansion of gears and casing. In actual operation, the gears become hotter than the casing, the thermal expansion causing the teeth to go more deeply in mesh. While this makes no difference whatever to the functioning of involute gears, with cycloidal gears it causes the contact to be heavy at the tips of the pinion teeth, where the relative sliding is greatest, a state of affairs always regarded as being inimical to satisfactory operation. Another advantage of the involute tooth is that it can be generated with a cutter having straight-sided flanks. The practice of rounding the bottoms of the interspaces between the teeth is very generally adopted. This small, though somewhat important, improvement, introduced in the early days of the use of gearing for ship propulsion, reduces the liability to tooth breakages through the development of corner cracks by stress concentration.

The question of the amount of clearance or backlash has been the subject of some controversy, and a desire to make it as small as possible has often been manifest. A small clearance is definitely dangerous practice; owing to the obliquity of the tooth flanks, the greater thermal expansion of the gear elements reduces the clearance. If it is reduced to zero, the teeth will jam. For a gear operating under normal conditions, the clearance should be sufficient to allow for a temperature difference of at least 80 deg. F. The reduction in tooth strength by adopting a reasonably large clearance is negligible and of no consequence, and the momentum that the gears can acquire in passing from ahead to astern flanks is so small that any momentary impacts of the teeth are quite harmless.

Practically all large-power gears are helical, mostly double-helical. The helical gear has many advantages over the straight spur gear, and, while these are generally well known, it is worth while to refer to the most important. A helical gear having a face width greater than one axial pitch has every phase of engagement simultaneously. If the ends of the teeth are suitably chamfered, each tooth comes into and leaves engagement without shock, despite the inevitable small deflection of the teeth already in engagement. The teeth have considerably greater strength than straight teeth, because the load is carried on several teeth, each carrying its portion of the load on only a part of its length, which is reinforced by the unloaded adjacent parts on either side of it. If the gears are made double-helical, the advantages obtained are that the equal division of load between the two half-lengths is definite, the torsional deflection is reduced, the duration of each cutting operation is much less, and alignment is facilitated by reason of the shorter lengths of the separate helices.

The construction of wheels has undergone little, if any, change for many years, the usual design giving every satisfaction. Mercantile gear wheels have the rims shrunk on to cast-iron spiders, with gaps between the arms to relieve casting strains, which gaps are afterwards filled in. The shaft is usually tapered where it passes through the boss, in which it is held axially by the usual nut. Wheels for vessels in which lightness of machinery is important are built up, a steel disc near each end connecting flanges on the boss and on the rim, which is in one piece, all being of mild steel. In some cases, the discs have stiffeners to prevent breathing or longitudinal pulsations. In American practice, it is quite usual to have cast-steel gear rims and hubs, either connected by mild-steel discs, etc., or all embodied in a single casting. The teeth are cut in the cast-steel rim.

When pinions have a length over the teeth exceeding three diameters, a central bearing is considered necessary to avoid excessive lateral deflection. This involves having three bearings in line on one shaft, which is not good design for high-speed shafts; but, fortunately, there is no difficulty in getting them properly aligned. No trouble has arisen from this source. In recent years, it has been possible to increase the load per inch width of gears, in many cases to such an extent that the reduction in length has enabled the central bearing to be dispensed with. This effects a great saving of weight, as both the wheel and gear case are correspondingly reduced in length. In early designs of gears without a central bearing, it was customary to reduce the gap between the helices to a minimum, to make the wheel helices as separate members, bolted together, and to make one pinion helix in the form of a sleeve secured to the pinion shaft. Gears can now be cut with such a small gap that there is not the necessity for this design, and double-helical pinions are invariably made from one solid forging.

Gear-case design has not undergone any noteworthy change. In this country, the gear case is usually cast iron and in two main parts, with a horizontal joint. In America, it is usually fabricated, the bearings being castings, and the remainder, welded-steel plates. In the case of double-reduction gears, it is usual to interleave the primary and secondary gears. In this country, the primary gears are almost invariably placed between the secondary gears. In America, it is common practice to dispose the secondary gears between the primary gears, the object being to reduce to a minimum the width and weight of the large secondary gears.

Materials must be of such quality that the teeth will not fail through (1) breaking off at the roots, or (2) fatigue of the metal at the surface of the tooth flanks. What is required, therefore, is a high fatigue limit in conjunction with great ductility. The materials in general use in this country to-day meet these conditions very satisfactorily under normal conditions of operation. The pinions are of 3½ per cent. to 5 per cent. nickel, 0·3 per cent. carbon steel of 40 tons tensile strength, 24 tons minimum elastic limit, and elongations

of 22 per cent. longitudinal and 16 per cent. to 20 per cent. transverse; the wheel rims are of mild steel of 31 tons to 35 tons tensile strength, and not less than 26 per cent. elongation. The Vespasian's pinions were of mild chrome-nickel steel (tensile strength, 37 tons to 38 tons; elastic limit, 32 tons), and they behaved excellently. In the early days of this vessel's service, these pinions were temporarily replaced by harder pinions of higher carbon steel, but teeth broke and the original pinions with their greater ductility were reverted to. The materials employed to-day were adopted about this time for marine gears, and have been adhered to in this country ever since; and the number of failures through breaking of teeth is practically negligible except for the period 1921-22, previously referred to.

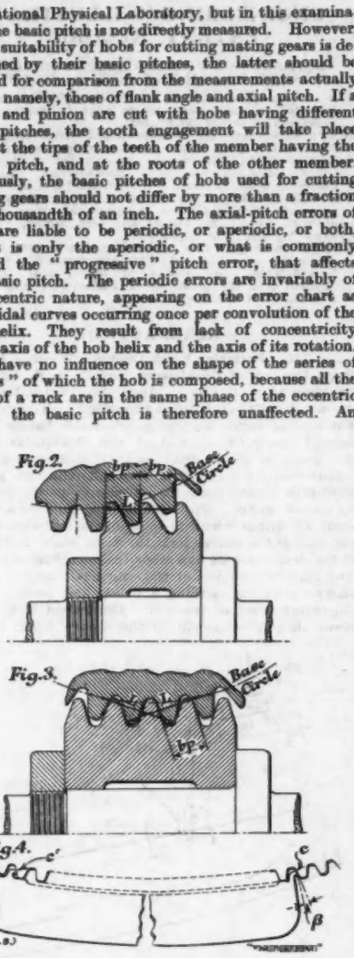
Tests on the strength of gear teeth were made at Turbinia Works about 1917, and it was found that, with gears of the standard form and materials, a static load of from 18 to 45 times the nominal load was necessary to cause deformation of the teeth. Quite obviously, with such large factors of safety, something abnormal must occur to cause breakages. Parsons and his colleagues attributed the failures in 1921-22 to incipient cracks caused in hardening the pinions by oil quenching, and since then the pinions of practically all mercantile marine gears have been normalised. This appeared to effect a complete cure, but it must be noted that hardening by oil quenching was continued with naval gears.

Another possible reason for those failures was the hammer-blow effects caused by the inaccuracies of the gears; but, although this would doubtless have a contributory effect, it would not be sufficient to increase the root stress to such an extent as to cause failure by fatigue in the short time the gears were in service. A further possible cause was the indifferent quality of materials. There were instances about that time of alloy steels proving defective and the defect being admitted by the steel makers. In the light of what has transpired since then, it would seem probable that the failures did, in fact, result from cracks set up in hardening, but that the real cause was defective material which was particularly liable to develop such cracks. The remarkably small number of such failures since then confirms that the factor of safety with present-day materials must be of the high order indicated by the static tests above referred to; and that the load on a modern gear is not limited by the root stress, but by the ability of the surfaces of the tooth flanks to resist distress by fatigue. All pinions should be bored throughout their length before heat treatment, to relieve contraction stresses and permit examination of the material with the aid of a borescope.

The necessity for accuracy arises in respect of (1) tooth form; (2) axial pitch; (3) angular pitch; and (4) smoothness of the tooth flank surfaces. The attainment of correct tooth form depends on the correctness of the shape of the cutting tool and of the generating motions of the machine. There is no difficulty in obtaining the correct motions, and the problem of obtaining correctness of shape of cutting tool is greatly simplified in the case of the involute gear by the fact that, if the rack form is used, the rack has straight generating edges.

In the production of large-power gears, continuous-motion indexing mechanism is almost invariably employed, as it is a practical necessity if creep mechanism is to be used. This necessitates that the cutting tools be hobs, and as it is desirable for practical considerations that right- and left-hand helices be cut, respectively, with right- and left-hand hobs, mating gears must be cut with different tools. In all cases, therefore, there is the problem of ensuring that the tools have truly complementary shapes. However, in the case of involute gears, the tools only need to be complementary in the sense that the normal distance between adjacent cutting edges is the same in both tools. This is seen in Fig. 2, on this page, which illustrates a method of generating involute gears devised many years ago with the object of eliminating cusps, by making the virtual diameter of the hob infinite. In this case, the cutting edges are perpendicular to the axis of the hob and the line of action L, parallel thereto. It will be clear that, if the distance $b\,p$ between the cutting edges, which may be called the basic pitch, is the same on two such tools, they will produce involutes which are exactly the same normal distance apart, and the gears cut by them will mesh properly at any centre distance. The hobs used in actual gear cutting invariably have cutting edges inclined to the hob axis with an inclination equal to the pressure angle of the gears to be cut, as shown in Fig. 3, which results in the cutting and running pitch points being coincident. In this case, the basic pitch is the normal distance $b\,p$ between the adjacent parallel cutting edges.

In the manufacture of hobs there has never been any difficulty in obtaining straightness and parallelism of the tooth flanks, and, with the "all-ground" hobs now used, the other errors are usually exceedingly small. Hobs used for finishing purposes are examined by the National Physical Laboratory, but in this examination the basic pitch is not directly measured. However, as the suitability of hobs for cutting mating gears is determined by their basic pitches, the latter should be derived for comparison from the measurements actually made, namely, those of flank angle and axial pitch. If a wheel and pinion are cut with hobs having different basic pitches, the tooth engagement will take place only at the tips of the teeth of the member having the longer pitch, and at the roots of the other member. Obviously, the basic pitches of hobs used for cutting mating gears should not differ by more than a fraction of a thousandth of an inch. The axial-pitch errors of hobs are liable to be periodic, or aperiodic, or both, but it is only the aperiodic, or what is commonly termed the "progressive" pitch error, that affects the basic pitch. The periodic errors are invariably of an eccentric nature, appearing on the error chart as sinusoidal curves occurring once per convolution of the hob helix. They result from lack of concentricity of the axis of the hob helix and the axis of its rotation. They have no influence on the shape of the series of "racks" of which the hob is composed, because all the teeth of a rack are in the same phase of the eccentric error; the basic pitch is therefore unaffected. An



eccentric error, however, does affect the accuracy of the shape of the involutes generated.

The profile of a gear tooth is generated by a series of cuts by successive hob elements, usually between 20 and 30 taking part in the finishing or generation; the profile is thus made up of a series of very narrow flats or facets. As the hob is fed across the work, a cutting element always cuts the same part of the flank of the teeth, and, therefore, if one element produces any defect of profile, this defect will run along the tooth from end to end. The defect produced by an eccentric hob is the equivalent of a variation in penetration, resulting in a deeper cut once per revolution, and between these deep cuts there is left a bulge or protrusion. The result is a series of lines of heavy bearing, usually two or three of them, running along the tooth flanks. If the eccentricity is considerable, most of the cutting elements of the hob take no part in forming the profile of the teeth, and the profile generated is not much better than would be produced by using a fly cutter. This defect is more likely to occur to a noticeable extent on pinion teeth, in which the curvature of the profile is greater than that of the wheel teeth. A true hob eccentrically mounted will produce exactly the same effect, and it is therefore essential that a hob be accurately mounted to rotate on its true axis. Modern hobs usually have at each end a plain cylindrical band, truly concentric with the cutting teeth, to facilitate checking the concentricity of their setting. Obviously, the difficulties both of manufacture and measurement are greater with hobs for cutting cycloidal teeth. The teeth of the hob must be of correct shape as well as truly complementary. If the usual practice is followed of cutting right-hand helices with right-hand hobs, and vice versa, four is the minimum number of hobs necessary to cut a double-helical gear, as against two with involute teeth. Fortunately, the defects in gears produced by inaccurate hobs are revealed when the gears are meshed with marking.

Axial-pitch errors are very difficult to detect by measurement, mainly because it is difficult to ensure, in a simple and readily applied gauge, that the measurement is being made along a line which is accurately parallel to the axis of the gear; however, discrepancies in axial pitch are readily detected visually by marking, so that actual measurement is not so necessary. The main factors to be observed in attaining accuracy of axial pitch are the use of an accurate feed screw, a straight slide on the gear-cutting machine, and correct alignment, both when cutting the gears and in their assembly. For many years now, feed screws of a high degree of accuracy have been readily obtainable, and this problem has been completely solved by the feed-screw manufacturers. The slide presents no difficulty, and, with proper care and attention, errors of alignment should not occur and, in any case, can be rectified. Misalignment in assembly can be rectified by adjustment of the bearings, and, in the case of misalignment in cutting the teeth, the obvious remedy is to recut. This involves a slight increase in the circumferential clearance (backlash) which, however, is in no way detrimental.

Angular-pitch errors are the most difficult to eliminate, mainly because there is no visible witness of their presence. They can only be detected by careful measurement. They are liable to occur in both periodic and aperiodic form. Such errors, of the periodic type, are most likely to be caused by non-uniform transmission by the indexing mechanism of the gear-cutting machine. This mechanism usually consists of a worm and worm wheel, and, since the worm passes through all the phases of its motion once per revolution, an error of its frequency is liable to occur; that is to say, the work is liable to have a series of errors equally pitched around its circumference and equal in number to the number of teeth in the worm wheel. In the operation of the gear the frequency of these errors is almost certain to correspond to a note within the range of audition; for example, a main gear wheel cut with an indexing worm wheel having 240 teeth would, at 100 r.p.m., produce small periodic accelerations and retardations with a frequency of 400 per second. This corresponds approximately to note G in the octave above middle C of the pianoforte scale and, therefore, could produce a shrill and unpleasant noise. Higher propeller revolutions would produce a still more shrill sound. The worm and worm wheel is a very convenient form of indexing mechanism for a gear-cutting machine, but it is difficult to obtain absolutely uniform transmission of motion with it, mainly because, considering, planes at right angles to the axis of the worm wheel, only in that passing through the axis of the worm are the gears involute; in all other planes, the intermesh is nondescript. Noise can be produced to an objectionable extent by periodic errors of exceedingly small magnitude, and errors of such magnitude are very difficult to eliminate in a worm and worm-wheel drive.

This problem was completely solved by the well-known "creep" mechanism invented in 1912 by Parsons, by means of which, in each succeeding revolution of the work table, the phase of the worm error is shifted; with the result that the corresponding errors in the work are distributed in spirals around the circumference instead of having a constant angular position across the width of the wheel face. At the time of this invention, careful measurements were made of the errors of transmission of the worm drives then in use for indexing purposes on gear-cutting machines. It was found that the amplitude of the periodic errors was liable to be of the order of 0·01 in., the error charts being substantially sinusoidal in form. Much greater accuracy is possible, and now it is even claimed that worm drives can be made to give absolute uniformity of transmission. While it may be possible to attain such extreme accuracy, it will certainly be difficult to maintain it in the practical job of cutting gears on a large scale. It is a much more practical policy to adopt a system where extreme accuracy, with mechanism which does not lend itself to such minute accuracy, is not a *sine qua non*.

Non-periodic errors of angular pitch were not effectively dealt with until about 1922. For many years, no practical method of measuring them had been evolved; only laborious academic methods were available. Measurement of the pitch of adjacent teeth was the usual practice, but it had little practical value as it revealed so little about the actual state of affairs; for example, for a wheel 100 in. in diameter with 1-in. pitch teeth, an eccentric error of 0·01 in. (an error hardly permissible to-day) would produce a maximum variation of the pitch of adjacent teeth of 0·0002 in., a variation which could be completely obscured by tool marks, etc. The practical elimination of these errors was imperative; the augmentation of the intensity of the normal load on the gears caused by the acceleration and retardation had to be rendered negligible. It was, and still is, the practice of gear manufacturers in other classes of work to employ what is known as a "speed factor," whereby the rate of loading of the gears is reduced as the peripheral speed is increased, in order to allow for this augmentation of the load; but speed is really a virtue, as regards load-sustaining property, by reason of its oil-film producing function, and for

this property to be nullified to some extent by the effects of load augmentation arising from angular-pitch errors could not be accepted as inevitable. Those errors had to be substantially eliminated.

Although, in the light of present knowledge, the problem does not appear to present any great difficulties, the fact remains that, despite the urgent necessity to reduce or eliminate these errors, it is not until 1922, when a satisfactory method of measuring angular-pitch errors was devised at Turbinia Works, that any real advance in this direction can be recorded—at all events, so far as the author is aware. This method, now well known and generally practised, consists in taking relative measurements of circumferential distances between teeth at consecutive equal intervals round the wheel, and, by a process of summation, calculating therefrom the errors of angular position of individual teeth. This type of gauge is shown diagrammatically in Fig. 4, page 59. It has contacts c and c', the distance between which is slightly different from the distance between the faces of the teeth at either end of the interval. One of the contacts rests on a tooth flank, and the distance β between the other contact and the corresponding tooth flank is measured. Two sets of retaining stops are provided, one to maintain the contacts in the same transverse plane during a gauging operation, and the other to maintain them at the same radial distance from the axis of the gear. These restraints are important, because it is absolutely essential to this method of gauging that, in measuring any interval, each contact must engage a tooth flank in precisely the same place as the other contact engages that tooth flank when measuring the adjacent interval. In other words, the measurements must be precisely "end to end." The length of the gauge between c and c' being constant, variations in the value of β indicate variations in the actual distances between the teeth gauged. The average areual length is the length of the gauge plus the average of the β measurements and, the length of the gauge being constant, it is only necessary to deduct the average β measurement from the actual measurement to obtain the variation in the length of the arc. When these variations are added algebraically (again "end to end"), the errors in relative angular disposition of the teeth gauged are obtained. If it is desired to know the accuracy of pitch of the intermediate teeth, each interval can be explored individually, dividing it into equal sub-intervals and measuring them in the same way. Fig. 4 is purely diagrammatic. With the actual gauge, the measurements are magnified by a multiplying lever and a dial micrometer so that differences of the order of 0·0001 in. can be measured.

(To be continued.)

CANADIAN STANDARD SPECIFICATIONS.

THE Canadian Engineering Standards Association has recently issued two new specifications and revised editions of two other specifications. The first of the new specifications, which bears the description C 68 (A)-1940, relates to paper-insulated lead-covered cable and constitutes the initial specification of a series dealing with insulated power cables. It is intended to apply to all sizes and classes of impregnated paper-insulated lead-covered cable used for the transmission and distribution of electrical energy, as customarily installed under average conditions. The specification has been prepared to govern the manufacture of high-quality cable, suitable for operation at specified rated voltages, and represents generally accepted Canadian practice.

The second new specification concerns insulated conductors for power-operated radio devices, and is designated C 22.2 No. 57-1940. This, together with a newly-issued second edition of specification C 22.2 No. 16-1940, relating to pull-off plugs for electro-thermal appliances, have been published under Part II of the Canadian Electrical Code, the requirements of which must be met in order to obtain the approval of the Canadian Engineering Standards Association for the electrical equipment concerned. Both of these C 22.2 standards have been prepared in collaboration with interested manufacturers and industrial associations, and are based upon laboratory tests and service performance. The last of the four recently-issued specifications bears the number B 29-1940, and consists of established lists of machine screws and of square and hexagon machine-screw nuts. This specification is a revision of a previous edition; it has been necessitated by developments which have taken place in the methods of gauging rolled-thread machine screws for commercial purposes and by the advisability of standardising Canadian and United States practice.

Copies of the four publications may be obtained from the Canadian Engineering Standards Association, National Research Building, Ottawa. With the exception of C 68 (A), which costs 1 dol., the price of the specification is 50 cents in each case.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

ABSTRACTS OF SPECIFICATIONS RECENTLY PUBLISHED UNDER THE ACTS OF 1907 TO 1939.

The number of views given in the Specification drawings is stated in each case; where none is mentioned, the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, etc., of the Communicators are given in italics.

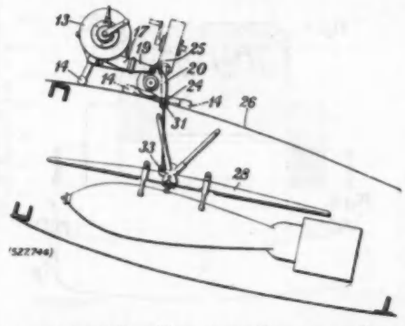
Copies of Specifications may be obtained at the Patent Office Sales Branch, 25, Southampton Buildings, Chancery-lane, London, W.C.2, price 1s. each.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

AERONAUTICS.

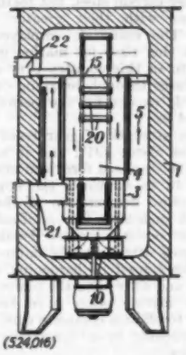
527,746. Portable Bomb-Loading Winch. Handley Page, Limited, of Cricklewood, and C. H. K. Napier, of Cricklewood. (2 *Figs.*) April 20, 1939.—The cable drum spindle is journalled in a housing 13 with two feet 14. For ease of bomb loading, a detachable handle can be applied either to one end of the spindle for turning the drum by direct drive or to the other end of the spindle to rotate the drum through reduction gearing. Provision is also made for alternative power operation by electric motor. From the housing projects a tubular strut 17 within which is rotatably mounted a tubular extension of a swivel fork 19, a set screw in the wall of the strut engaging in a groove in the tubular extension. The reaction member of the winch is constituted by a sheave block 20 carrying a pulley and formed with a depending reaction tube 24. The swivel fork 19 can pivot slightly relatively to the sheave block about a



horizontal axis 25. 26 represents the upper surface of the wing, inside which is the bomb carrier 28. At one side of a hand hole in the upper surface of the wing is a socket 31 located at the hoisting point to receive the reaction tube 24. This socket is accessible, together with the bomb release electrical connections, on removal of the hand-hole cover. The lower end of the cable carries a ball which can be engaged on the ground with a fitting 33 on the bomb carrier. After the bomb has been hoisted into position, the ball is released from the fitting and drawn up through the socket 31, whereupon the winch can be removed and transferred to a fresh socket to hoist another bomb into position. The articulated joint between the housing 13 and the sheave block 20, constituted by the horizontal pivot 25 and the rotatable connection between the strut 17 and the fork 19, enables the housing to accommodate itself to any curved or sloping surface, the winch operating equally well when the housing occupies the position shown in chain-dotted lines. Due to the fact that the load is concentrated on the socket 31, it is only necessary to strengthen the wing structure in the vicinity of this socket, the remaining portion of the wing covering needing only to take the weight of the winch and operator. (*Accepted October* 15, 1940.)

FURNACE APPARATUS.

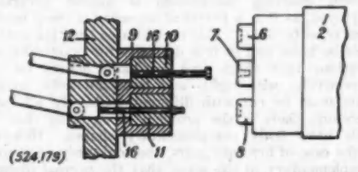
524,016. Furnace. Wild-Barfield Electric Furnaces, Limited, of London and J. E. Oram, of London. (2 *Figs.*) December 22, 1938.—The furnace is of the type in which air is circulated in a closed circuit within the furnace by a fan. The furnace chamber 1 is mounted on feet with its axis vertical. Within the furnace chamber is a partition 3 coaxial with the wall of the furnace, which divides the chamber into an inner treatment chamber 4 and an outer annular chamber 5 containing the electrical heating elements. The partition 3 terminates short of the top of the furnace chamber and has a throat at the bottom. Between this throat and the bottom of the furnace chamber is a paddle type fan 10, the axial inlet to which is in alignment with the throat. The fan is driven by a motor outside the furnace. The fan draws air down through the inner chamber 4 and forces it outwards to the annular chamber 5. It then rises past the heating elements and over the top of the partition to pass down again through the treatment chamber. At opposite sides of the chamber 4 are pairs of endless chains 15, which run over wheels at the top and bottom. One straight length of each chain passes through the treatment chamber and the other straight length moves in a groove in the furnace walls. The chains carry angle-



iron brackets 20 which support perforated trays on which the work is placed, the trays being raised through the furnace by the chains. Towards the bottom of the furnace chamber and above the bottom end of the chain elevator, an opening 21 is formed in the furnace wall, through which loaded trays are passed on to the elevator. Towards the top of the furnace chamber a similar opening 22 is formed through which the loaded trays are withdrawn. By this arrangement the heated gas comes first into contact with the hottest batch of work in the furnace, thus increasing the efficiency of transfer of heat. (*Accepted July* 29, 1940.)

MACHINE TOOLS AND MACHINE-SHOP EQUIPMENT.

524,179. Bolt-Head Forging Machine. Greenwood and Batley, Limited, of Leeds, and J. C. M. Maclagan, of Leeds. (10 *Figs.*). January 24, 1939.—The machine forms heads on bolts by cold forging where the bolt head is of such size as to require two blows from the heading punches to form it. A heading slide 2 is operated by a pitman from the driving crankshaft and its outer end carries a fixed punch block in which are fitted three punches 6, 7, 8, arranged in line and equally spaced. The centre punch 7 is a first or coning punch and the other two are second or finishing punches. A die block 9 inside the bed of the machine carries two dies 10, 11 in the same plane as the punches 6, 7, 8, and correspondingly spaced. The die block is attached to a reciprocating shifter slide 12 operated by a link and arm from a rocker shaft, which is driven by cam mechanism at a 2 to 1 reduction from the crankshaft, a dwell period being provided at the end of each stroke. With the die holder at one extreme end of its travel, the die 10 is in alignment with the centre or coning punch 7 and the other die 11 is in alignment with the finishing punch 8,



while in the other extreme position the die 11 is in register with the coning punch 7 and the other die 10 is in alignment with the other finishing punch 6. A cut-off slide is provided to cut off the wire stock and carry each cut-off blank across to the centre line of the die to receive it. The operation of the machine is as follows:—The blank of wire stock is carried across to the centre line of the die when the heading slide 2 is retracted, and is held there until the coning punch 7 pushes the blank into the aligned die and up against its ejector pin 16, the wire left projecting beyond the die face being upset or coned. The slide is now retracted and a second blank is cut off and presented to the other die, which the shifter slide has moved into the loading position in register with the coning punch, while the die carrying the coned blank has been brought into register with a finishing punch. Thus, upon the next heading stroke of the slide, the coned head on one wire blank is completed by the finishing punch and the plain blank is partly headed by the coning punch. The slide 2 again recedes, the finished bolt is ejected, and the shifter slide is moved back to its original position. The sequence of operations is then repeated. (*Accepted July* 31, 1940.)